THE COMMONWEALTH OF AUSTRALIA

FEDERAL HANDBOOK

PREPARED IN CONNECTION WITH THE EIGHTY-FOURTH MEETING

OF

THE BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

HELD IN AUSTRALIA,
AUGUST, 1914.

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EDITED BY
G. H. KNIBBS, C.M.G., F.R.A.S., F.S.S.

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PREFACE.

This Handbook, specially prepared for the use of members of the British Association for the Advancement of Science, at the Australian Meeting of 1914, contains a series of articles written by persons selected for that purpose by the Federal Council in Australia. These articles set forth matters which, it is believed, will be found of interest, and the data of which are in most cases not readily accessible to general readers abroad, nor even to those in Australia. Much of the material also has not hitherto been published.

The issue of the Handbook has been made possible by the generosity of the Federal Government of Australia in undertaking to defray the expense of publication. That Government also has very kindly placed all desired official sources of information in its possession at the disposal of the Editor.

The articles were decided upon by the Federal Council in Australia of the British Association for the Advancement of Science, in whose name the invitation was made to each of the writers to contribute. Each author is alone responsible for all statements made or opinions expressed in his article.

The closing chapter refers to miscellaneous matters worthy of mention which were not covered by the preceding chapters.

G. H. KNIBBS,

Editor.

Melbourne, March, 1914.

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* Besides the above, there are several small maps, diagrams, etc., inserted in the text.

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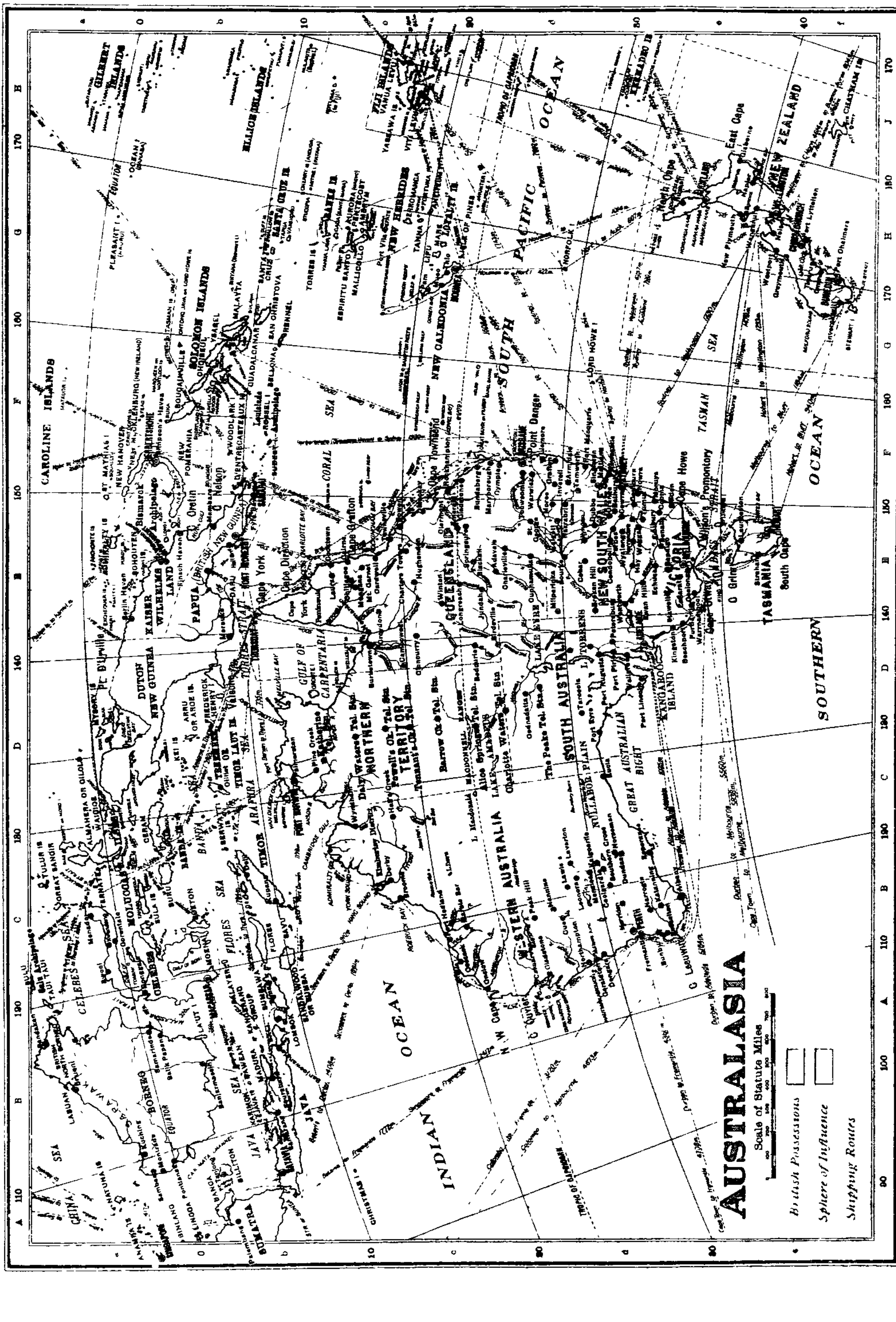

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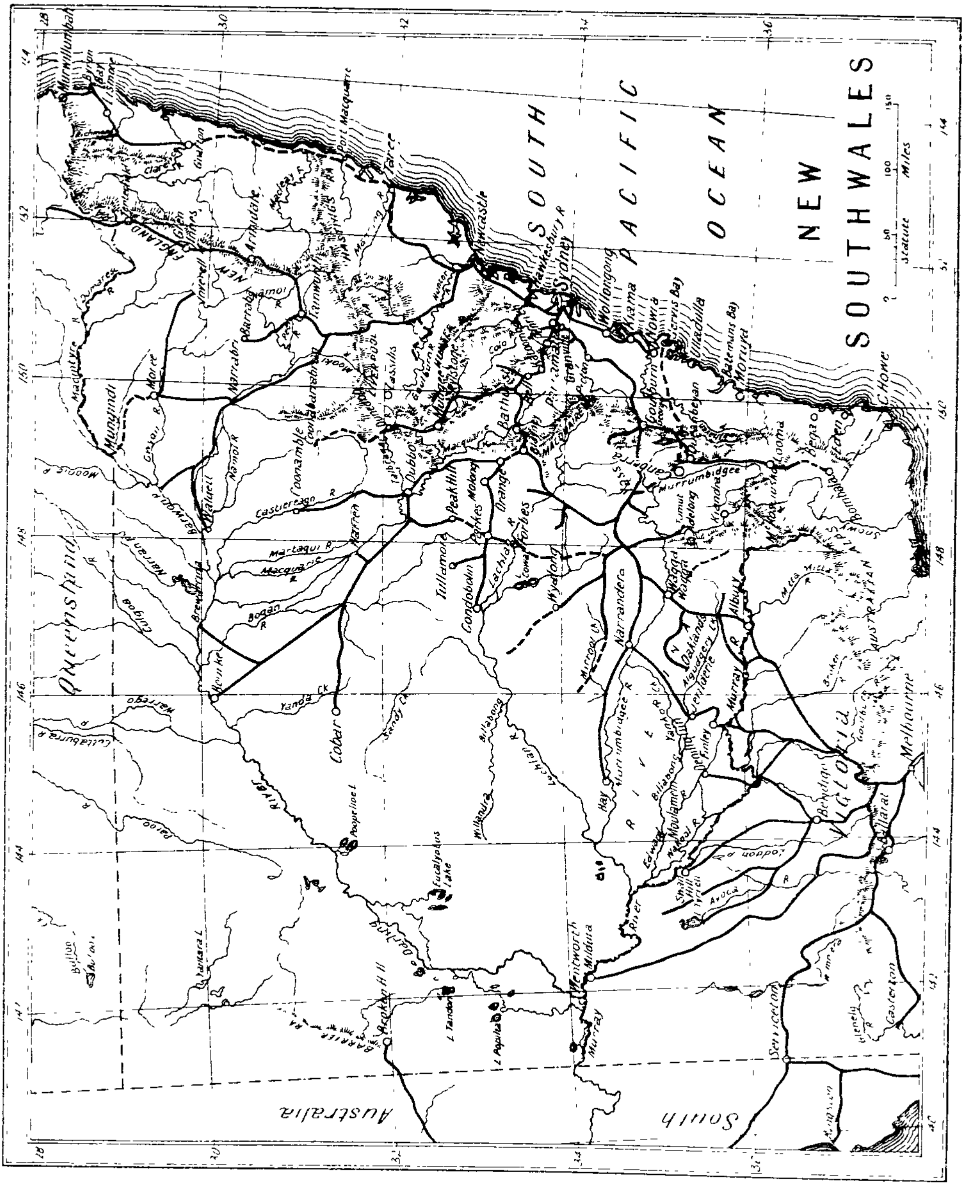
NEW SOUTH WALES
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Melbourne
Bourke
Cobar
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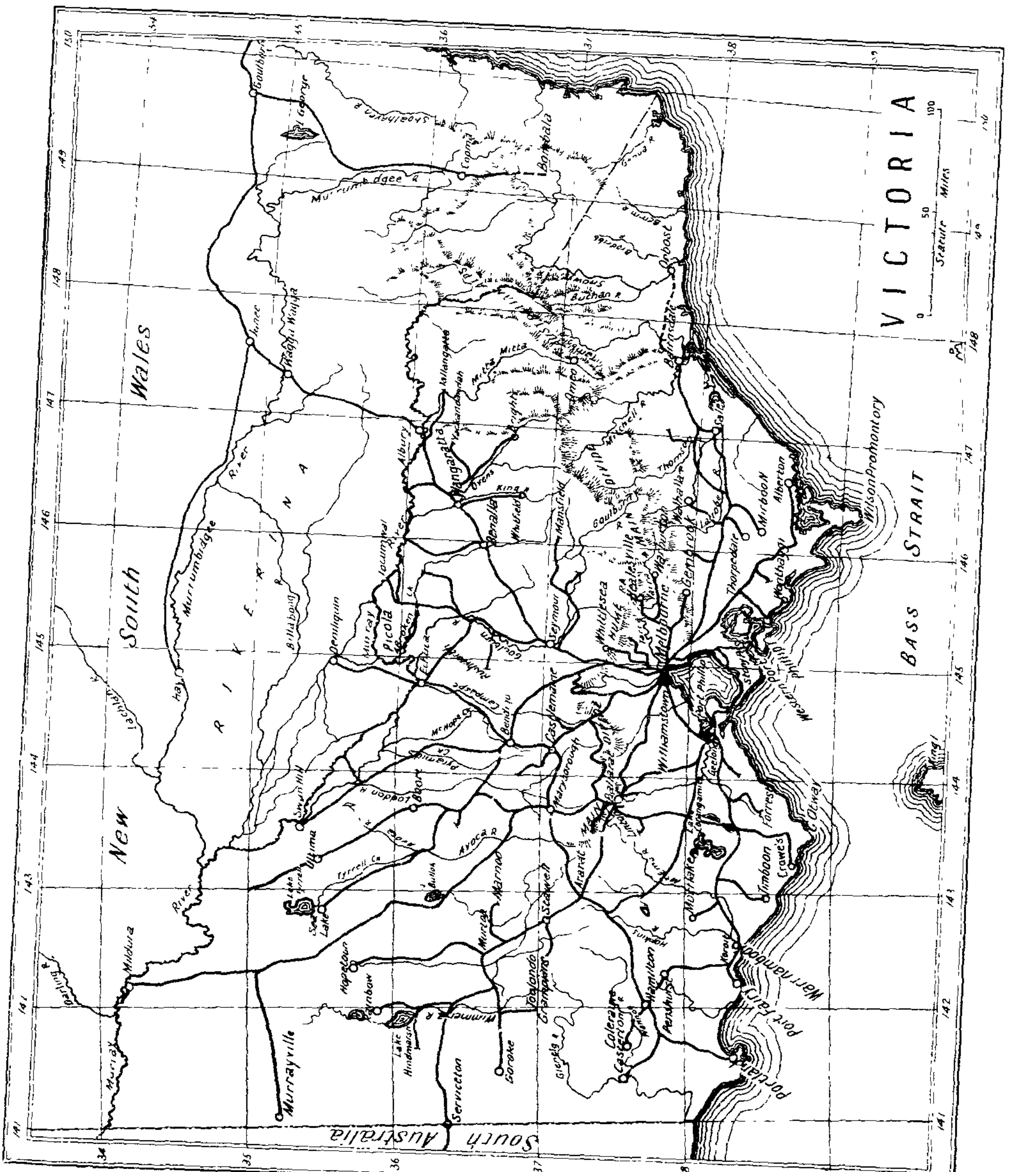
Albury
Statute Miles


VICTORIA
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New South Wales
South Australia
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RIVERINA
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Port Phillip
Geelong
Ballarat
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Castlemaine
Echuca
Albury
Wangaratta
Benalla
Seymour
Mildura
Murrayville
Serviceton
Portland
Port Fairy
Warrnambool
Hamilton
Stawell
Ararat
Maryborough
Gippsland
Colac
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Bairnsdale
Orbost
Omeo
Murrumbidgee R.
Murray
Goulburn
Deniliquin
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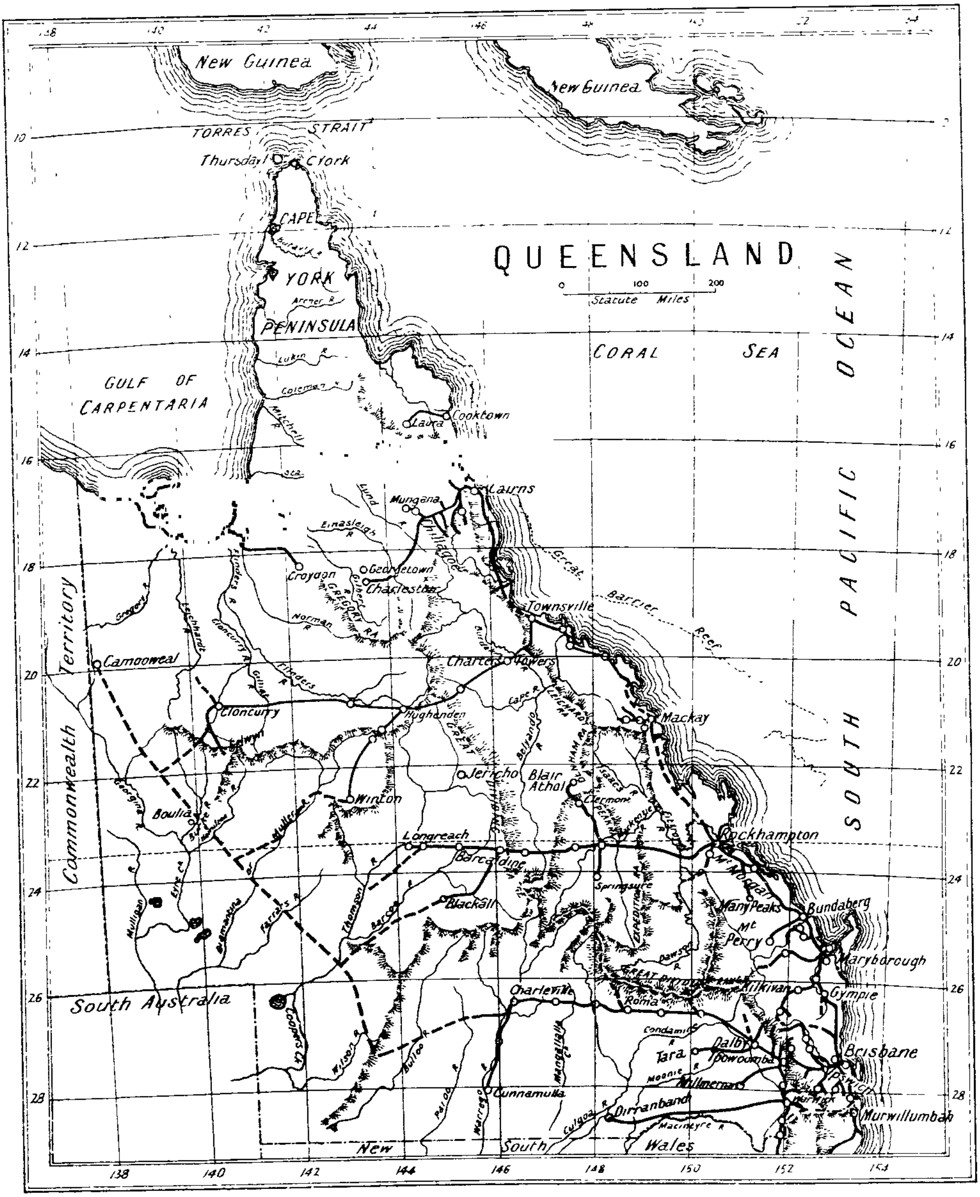
QUEENSLAND
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New Guinea
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GULF OF CARPENTARIA
CORAL SEA
PACIFIC OCEAN
SOUTH PACIFIC
Cooktown
Laura
Cairns
Croydon
Georgetown
Charleston
Townsville
Charters Towers
Camooweal
Cloncurry
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Mackay
Winton
Jericho
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Longreach
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Tara
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South Australia
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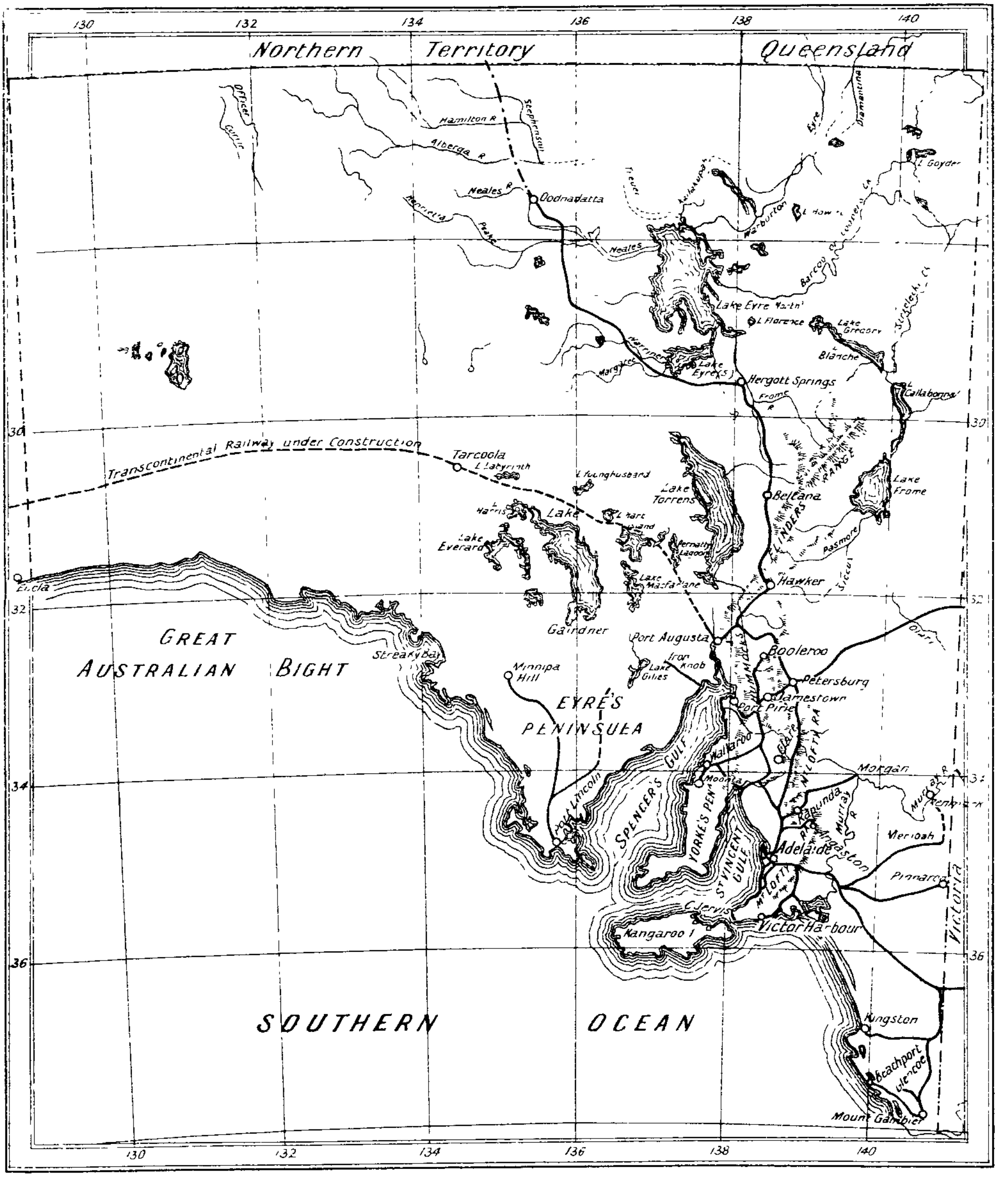

SOUTH AUSTRALIA

0 50 100 150

Statute Miles


WESTERN AUSTRALIA
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Statute Miles
INDIAN OCEAN
South Australia
GREAT AUSTRALIAN BIGHT
Wyndham
Derby
Broome
Kimberly
Hall's Creek
Condon
Pt Hedland
Cossack
Pilbarra
Marble Bar
Nullagine
Onslow
Tropic of Capricorn
Carnarvon
Sharks Bay
Peak Hill
Meekatharra
Nannine
Wiluna
Cue
Sandstone
Mt Magnet
Yalgoo
Geraldton
Dongara
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Kanowna
Kalgoorlie
Coolgardie
Wongan Hills
Bullfinch
Bolgart
Southern Cross
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Northam
York
Perth
Freemantle
Norseman
Dundas
Narrogin
Wagin
Katanning
Bunbury
Busselton
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Tambellup
C Leeuwin
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L. Austin
L. Baron v Müller
L. Barlee
L. Monger
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L. Raeside
L. Carey
L. Lefroy
L. Cowan
Fitzroy R.
Margaret R.
Mary R.
Ord R.
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Oakover
Davis
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Hardey
Duck
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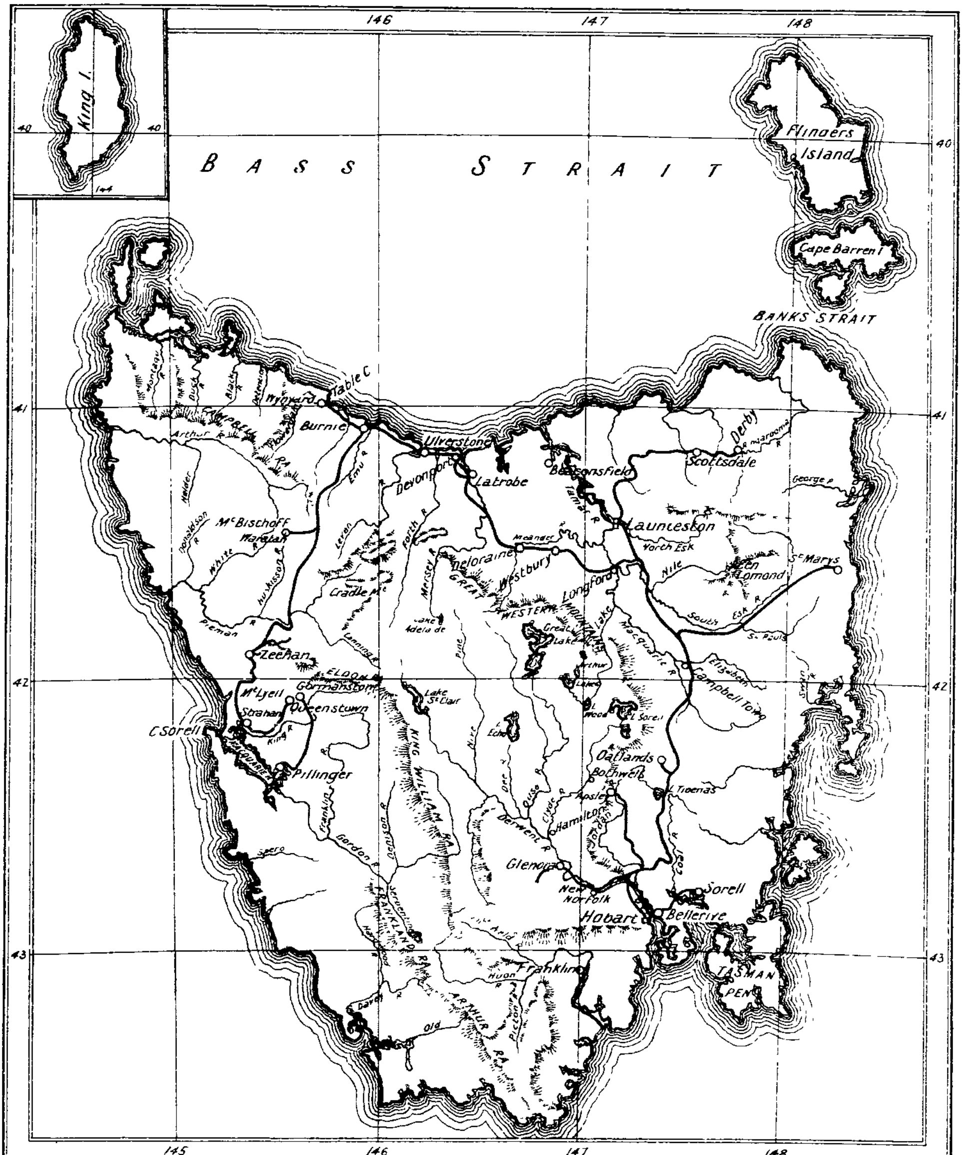

TASMANIA

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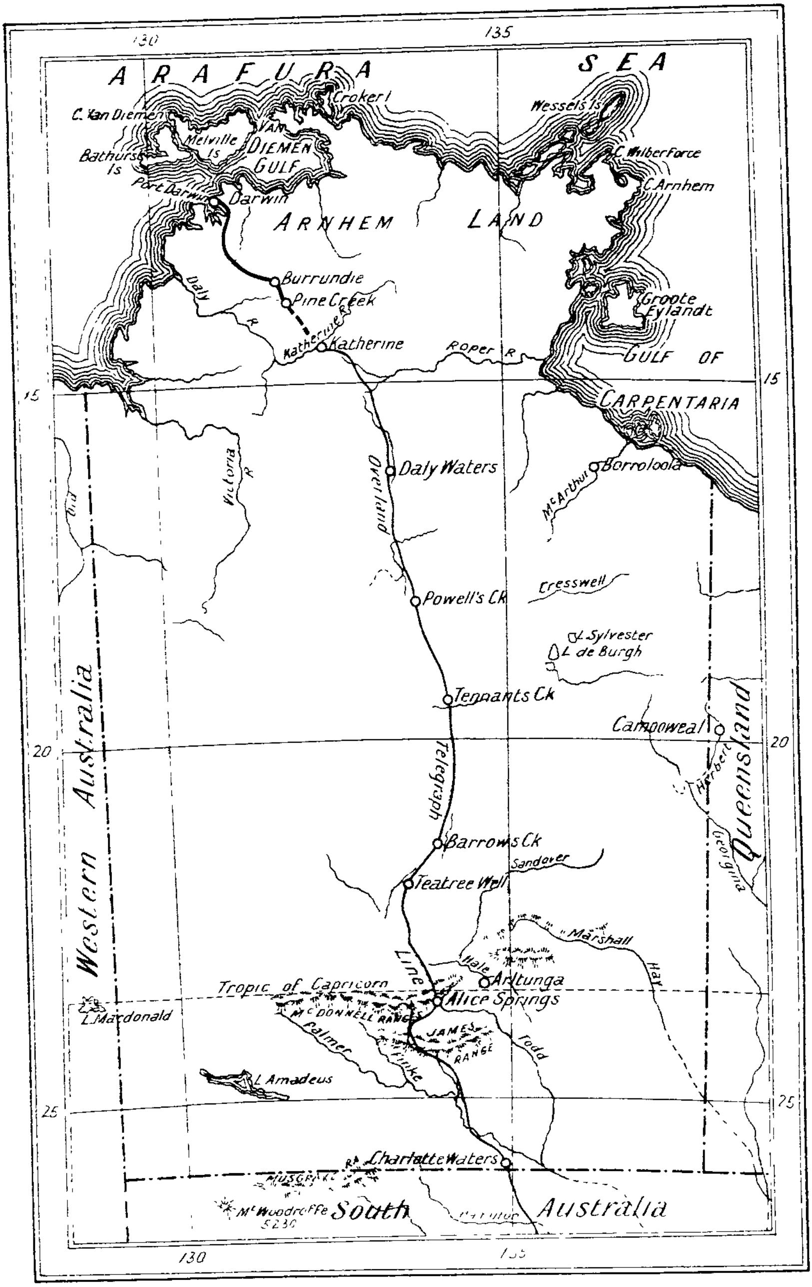
Statute Miles



NORTHERN TERRITORY

0 100 200
Statute Miles

CHAPTER I.

HISTORY OF AUSTRALIA.

By Ernest Scott, Professor of History in the University of Melbourne.

SYNOPSIS.

1. The Name of Australia.

The name Australia was given to the great southern continent by Matthew Flinders, the navigator. Before his time, it was generally called New Holland; but, as he pointed out, the Dutch had known nothing of the southern and eastern coasts, whilst the name New South Wales, which Cook gave to the eastern portion, could not be applied to the whole country, since Cook had known nothing of the west, north-west, and south. Flinders wanted a convenient name that would describe the entire area which his own researches had demonstrated to be one large island. He was writing his *Voyage to Terra Australis* while held a prisoner by the French in Ile-de-France (Mauritius), from 1803–1810, and it occurred to him that "Australia" would be a good, serviceable name. He did not invent the word. De Brosses, in his *Histoire des Navigations aux Terres Australes* (Paris, 1756), had coined the word "Australasia" as a name for a division of the globe, and Dalrymple, in the preface to his *Historical Collection of Voyages and Discoveries in the South Pacific Ocean* (London, 1770), suggested "Australia" as a name for the region east of South America. Shaw and Smith, in their *Zoology and Botany of New Holland* (1793), spoke of "the continent of Australia, Australasia or New Holland," but it is not probable that Flinders had ever seen their book. He sought to secure official sanction for the adoption of the name for this continent. He used it repeatedly in his correspondence after 1804, and first employed it publicly in a geographical paper, written in French, and published by Malte-Brun, in the *Annales des Voyages* (Paris, 1810). But he was by no means sure that the innovation would be approved. "Il reste a savoir," he wrote, "si ce nom sera adopté par des géographes européens." When he was liberated and returned to England, he endeavoured to bring the name into official use, but Sir Joseph Banks was not favorable, and Arrowsmith, the publisher of Admiralty charts, "did not like the change" because his firm had always employed "New Holland" in their publications. The history of Flinders' explorations, which was semi-official, was therefore issued under the title *A Voyage to Terra Australis*, and the name Australia was merely suggested in a footnote "as being more agreeable to the ear and an assimilation to the names of the other great portions of the earth."* He was to some extent "tongue-tied by authority," and the name "New Holland"

* *A Voyage to Terra Australis* (London 1814) Vol I., the history of the name is discussed in the writer's *Life of Matthew Flinders* (Sydney, 1914) chapter 30.

was used in official despatches for 40 years after he had recommended the more convenient designation, though Governor Macquarie, in a despatch of April, 1817, expressed the hope that "Australia" would in future be employed, and Peter Cunningham, the botanist, in his *Two Years in New South Wales* (1827), referred to "Australia, as we colonials say."* But Flinders' choice has been abundantly justified, and there is some satisfaction in remembering that the name borne by Australia was given to her by one of the most intrepid and skilful of her maritime explorers, and one who was in the full sense a man of science.

2. Coastal Exploration.

There is no sound historical evidence to support the belief that any part of Australia was known to Europeans before the end of the sixteenth century. The Portuguese rounded the Cape of Good Hope in 1497, and their ships began to employ the Cape route to Calicut and the East Indies after 1498. The Spaniards rounded Cape Horn, crossed the Pacific, and reached the Philippines in 1521. But if either Portuguese or Spanish ships sighted Australia, west or east, before 1606, record of the fact has not yet come to light. Speculation points to the persistence of rumours about a southern Terra Incognita, or Terra Australis, and it may be considered probable that at a period when it was not unusual for a ship to be blown hundreds of miles out of her course, some part of the coast may have been seen. But proffered "proofs" of very early discoveries prove nothing except the existence of a vague sense of what proof is. That the Dutch knew of Australia before the dawn of the seventeenth century is clear. In 1598, Cornelius Wytfliet wrote of Terra Australis as the most southern of all lands, and as separated from New Guinea by a narrow strait. That is definite and true; but the Dutch writer mentioned no particular ship that had sailed through the strait. We come in contact with an actual navigator who had some part in the story in connexion with the voyage of Pedro Fernandez de Quiros, in 1606.

Quiros, in command of two Spanish ships, discovered the New Hebrides, and thought he had found the great continent which he believed to exist at the southern end of the globe. He called it Austrialia del Espiritu Santo. The first word in the name is supposed to contain a compliment to Philip III. of Spain, who also ruled Austria,† and is not the source whence "Australia" is derived. Quiros sailed east for Peru, but his second in command, Luis de Torres, took a western course, and found the strait lying between Papua and the northern extremity of Australia. In the same year the Dutch ship *Duyfken* entered the Gulf of Carpentaria, and her captain reported on reaching Java that there was no passage through to the Pacific in that neighbourhood.

The Dutch became acquainted with the west coast partly through a series of accidents, partly in consequence of a change of route to the East Indies. Prior to 1611, their customary course after rounding the Cape of Good Hope was north to Madagascar, and then in a direct line east to Java or north-east to India. But it was discovered that by sailing about 3,000 miles due east from the Cape, ships met with favorable winds, and could then run

* M. Phillips, *A Colonial Autocracy*, p. 2.
† See Markham, *Voyages of Quiros* (Hakluyt Society) Vol. I. p. xxx.

north to Java, and complete the voyage from Holland in several months less than by taking the route to Madagascar in the first instance. The consequence of this change of route, which was ordered by the directors of the East India Company, was that ships voyaging from the Cape to the East Indies frequently found themselves off a strange, desolate coast, which one captain after another marked down upon his charts, until the whole outline from the Gulf of Carpentaria to the south-west corner, at Cape Leeuwin, was mapped. The best known of the Dutchmen who stumbled upon the western coast in this manner was Francis Pelsart, whose ship in 1628 ran aground on the Abrollos Reef. In 1642 the Governor of Java, Antony van Diemen, wishing to know more of these southern lands, despatched an experienced navigator, Abel Tasman, with two ships, the *Heemskerk* and the *Zeehan*, on a voyage of exploration. Tasman discovered the island which now bears his name, though he did not know that it was an island: and he called it Van Diemen's Land, "in honour of the Governor-General, our master, who sent us out to make discoveries."

The first Englishman to visit Australia was William Dampier, who, first in 1686, on board a buccaneering ship, the *Swan*, and secondly, in 1699, in command of the *Roebuck*, sailed along the western and north-western coasts. He was not impressed by what he saw of the country. "If it were not for that sort of pleasure which results from the discovery even of the barrenest spot upon the globe," he wrote, "this coast of New Holland would not have charmed me much." It was owing to the fact that the Dutch and Dampier always saw Australia from that aspect where it looks most forbidding, that attempts to ascertain the nature of the country, its possibilities of development, and its capabilities for settlement, did not ensue for 190 years after its whereabouts were definitely known.

The voyage of James Cook in 1768–70 brought the east coast of Australia for the first time to the knowledge of the English Government. The main object of Cook's *Endeavour* voyage was not to explore, but to observe a transit of Venus at Tahiti. The observation was made on 3rd June, 1769. After fulfilling the appointed duty, Cook ran down to New Zealand, and sailed round it, thus disposing of a theory entertained before his time that the country formed part of a great antarctic continent. He resolved to return to England by way of the East Indies, and to follow the east coast of New Holland wherever it might lead. The *Endeavour* sighted the Australian coast opposite Cape Everard at six in the morning on 20th April, 1770. Cook named the point Cape Hicks, after Lieutenant Hicks, the officer on watch, who was "the first to discover this land." He followed the coast northward, discovered Botany Bay (at first called Stingray Bay) on 29th April, and anchored there. On 6th May, the *Endeavour*, pursuing her voyage, came abreast of Port Jackson, which was named after Sir George Jackson, one of the Secretaries to the Admiralty. Cook did not enter the harbor, which is now the glory of the largest city in Australia. He completed his northward voyage, cleared the reefs of Torres Strait, and "took possession of the whole eastern coast by the name of New South Wales."*

* It has been said that Cook did not originate the name New South Wales, and it is true that the name does not appear in his journals. Bladen, the editor of the *Historical Record of New South Wales* (I. 170), goes so far as to say that "the name appears to have originated with Hawkesworth," who edited Cook's voyage. But Kitson (*Life of Cook*, p. 149) cites a letter written by Cook 1771 wherein he uses the words "the east coast of New Holland or what I call New South Wales." Hawkesworth, it would therefore appear, obtained the name from Cook himself.

The exploration of the Australian coastline was not completed until after the British had commenced to colonize the country. In 1797 Surgeon George Bass, of H.M.S. *Reliance*, obtained from Governor Hunter the use of a whaleboat, a crew of six bluejackets, and provisions for six weeks. With this equipment, he left Port Jackson, voyaged southward, and discovered Westernport (January, 1798). He did not actually demonstrate the existence of a strait separating Australia from Tasmania, but the heavy sea rolling in from the westward gave him "much reason to conclude" that there was a passage through. In October, 1798, Bass, in company with his friend, Lieutenant Matthew Flinders, sailed through the strait in the *Norfolk*, 25 tons, and circumnavigated Tasmania.

In 1802 Lieutenant John Murray discovered Port Phillip: Grant, in the *Lady Nelson*, sailing from the Cape of Good Hope to Australia, came upon the coast near Cape Banks, and discovered the stretch eastward, round Cape Otway, to the Port Phillip opening; and Flinders, in the *Investigator*, thoroughly explored the whole of the south coast from the head of the Great Australian Bight. He discovered Kangaroo Island and St. Vincent's and Spencer's Gulfs. In Encounter Bay he met *Le Géographe*, Captain Nicholas Baudin, a French exploring ship sent out by the Consular Government, Napoleon having acceded to a request submitted by the Institute of France that a scientific expedition should be despatched to examine the unknown coasts of New Holland, and to collect specimens for the Museum at Paris. Baudin died before his ships returned to France, and the maps published with the history of his voyage affixed the name Terre Napoléon to the whole southern coast from Wilson's Promontory to the head of the Bight. Some writers have attached a political significance to the Terre Napoléon maps, but in the present writer's opinion the name was a mere piece of courtiership, and there is no evidence to show that Napoleon ever designed to acquire territory in Australia, though at a later date (1810) he directed his fleet based upon Mauritius to "take Port Jackson," where much-needed provisions could be found.*

Flinders circumnavigated the continent in 1803, and after his very remarkable voyages there was no more coastal exploratory work to do in Australia, except to fill in details.

3. The Foundation of Settlement.

In 1783, James Matra, who had been a midshipman with Cook, submitted to Lord Sydney a scheme for establishing in New South Wales a colony wherein Great Britain might afford an asylum to the American loyalists, who had been rendered homeless by the result of the War of Independence. The country, Matra urged, was bound by every tie of honour and gratitude to protect and support those who had risked everything in support of British rule in North America, and should provide a place where they might "repair their broken fortunes and again enjoy their former domestic felicity." The loyalists found homes in Canada, but Lord Sydney recognised that Matra's plan afforded a means of overcoming another difficulty with which the Government was faced. It had been customary to ship convicts to America, where,

* See the writer's *Terre Napoléon* (London, 1910).

especially in the southern States, there was a demand for labour. Contractors were willing to undertake to convey convicted persons across the Atlantic. and were able to dispose of them by "assignment" to purchasers, who would often give £8 or £10 for a strong male convict, especially if he were a mechanic. The prisoners were, in fact, sold into servitude. The establishment of the United States as an independent country put an end to this traffic. At the same time, the English prison system was discreditably bad Gaols were too few, and too small; were overcrowded, dirty, and centres of disease. Lord Sydney, discussing Matra's scheme with its author, pointed out that New South Wales appeared to be "a very proper region for the reception of criminals condemned to transportation." Matra accordingly amended his project, drawing up an addendum wherein he argued for the reformatory efficacy of a colony far removed from Great Britain, with a healthy climate, and an abundance of fertile soil, where persons who had been guilty of crimes might work out their own redemption. Sir Joseph Banks, who had been botanist with Cook, and was now (since 1778) President of the Royal Society, gave the scheme his hearty support: and in 1786 the Government directed the equipment of a fleet to convey 750 convicts to Botany Bay.

Arthur Phillip, a captain in the Navy, was chosen to command the expedition, which consisted of the *Sirius*, a sixth rater, the *Supply*, tender, six transports, and three store ships. There were about 1,100 people aboard, of whom 208 were marines to guard the convicts.

The whole fleet had arrived at Botany Bay by 20th January, 1788, but Phillip was soon convinced that the situation was quite unfit for the purpose. He therefore judged it advisable to examine Port Jackson, which was marked on Cook's chart a few miles to the northward. There he "had the satisfaction of finding the finest harbor in the world, in which a thousand sail of the line may ride in the most perfect security." Returning to Botany Bay, he ordered the fleet to sail round to Port Jackson, and on the 26th January the flag was unfurled at Sydney Cove, where Phillip had decided to plant his new settlement.

While the British vessels were lying at anchor in Botany Bay, two French ships under the command of Lapérouse appeared. It has been by some writers surmised that the French navigator was endeavouring to forestall the English in the occupation of Australian soil. One historian puts it that "it is seizure, not discovery, which gives a title by the law of nations, and there is therefore some justification for saying that England won Australia by six days."* But it is quite certain that Lapérouse had no such acquisitive design in view. His longboat had been destroyed, and some of his company were massacred by natives in Samoa. Consequently his strength was so seriously depleted that if he had lost any more men he would have been compelled to beach and destroy one of his ships. Wishing, therefore, to put together a new longboat, the frame of which he had in the hold, he decided to sail to Botany Bay—knowing its whereabouts from Cook's Chart—where he thought his men would be able to work without interference. The French remained there from 27th January to 15th March, on excellent

* Jenks, *History of the Australasian Colonies* (1895), p. 30. See the present writer's *Lapérouse* (Sydney 1912).

terms with the British officers who visited them. Phillip was too busy laying the foundation of Sydney to visit Lapérouse personally, and the French navigator did not enter Port Jackson.

The difficulties that Phillip had to encounter during the four years of his governorship were of the most serious kind. The officers quarrelled, the convicts were poor material for pioneering, skilled workmen were few, supplies were wholly insufficient, and provision ships were wrecked. Over a thousand more convicts were sent out, and an additional thousand were announced, before there was accommodation for them or food to feed them. The natives gave trouble, and the Home Government failed to appreciate the need for a steady supply of free agricultural and artisan settlers. But Phillip did at length get the colony on its feet, and for the wisely planned and energetically pursued administrative work that he did he is indeed memorable as one of the veritable builders of the British Empire.

4. The Convict System.

After the departure of Phillip, the colony was for three years administered by officers of the New South Wales corps: by Major Grose during 1793 and 1794 and by Captain Paterson during 1795, when Governor Hunter succeeded. Phillip had ideas of extending development by means of free settlers aided by the use of convict labour; but for over twenty years Sydney was little better than a prison compound, walled by mountains and fronted by the sea, wherein felons, political offenders, and many an unfortunate whose punishment was cruelly out of proportion to his offence, were "yarded" together under a discipline enforced by the lavish application of the lash. During the first seventeen years of settlement 12,290 persons were transported, and as late as 1810 it is calculated that there were not more than 700 settlers who had not been sent out "for their country's good." The prisoners included a considerable number of political prisoners who had been convicted for connexion with the Irish rebellion of 1798, and the Scottish revolution societies of 1793: just as at a later date working men concerned with the beginnings of English trade unionism were transported. During the governships of Hunter, King, and Bligh, from 1796 to 1809, no serious efforts were made to induce free settlement, which was, indeed, at times rather discouraged.

The study of the historical material relating to these years of dark dawning is often painful and depressing. An atmosphere of hatred, violence, and suspicion pervaded the colony. Every Governor was perplexed and hampered, not only by the refractory human material with which he had to work, but by the jealousy of his officers. King was a high-minded man, but he found no loyal spirit of co-operation among his subordinates. The officers of the New South Wales corps made large profits by trafficking in rum, and the endeavour to suppress the iniquities of the trade provoked resentment, followed, in Governor Bligh's case, by open mutiny.

The quarrel between Bligh and John Macarthur, a bold, spirited, and hot-tempered officer, who founded sheep-farming in Australia, was pricked to a crisis in 1807, when the Governor confiscated a still which Macarthur had imported. Bligh, incensed by Macarthur's "inimicability of mind to Government," had him arrested and put on trial. But Macarthur had a large

personal following, and Bligh's arbitrary methods had made him unpopular. Major Johnson, who commanded the military forces, refused to obey his orders, and followed up his act of insubordination by marching his troops to Government House and arresting the Governor. He took this revolutionary step (January, 1808) on a requisition signed by Macarthur and about 100 of the inhabitants of Sydney, some of whom, Bligh declared, "are the worst class of life," but who at all events pledged themselves to support Johnson with their fortunes and their lives. Bligh was kept in confinement for a year, the affairs of the colony being administered by Lieutenant-Colonel Paterson, of the Van Diemen's Land settlement, who held a Lieutenant-Governor's commission. The end of this startling incident was that Johnson was tried by court-martial in England, and cashiered; Macarthur, who went to England, was prohibited from returning to New South Wales for eight years; and Bligh was superseded in the Governorship by Colonel Lachlan Macquarie.

Macquarie was hardly less dictatorial than his predecessor had been; and the long period of his rule is fairly described in the title of the book wherein it is most thoroughly explained, *A Colonial Autocracy*.* He was vain, and could be quarrelsome and harsh. But he had a way of getting things done. He was a builder, a colonizer, a statesman, and as his obstinacy was exerted in a progressive direction, he managed to fight through prejudices and hindrances to merited popularity. One principle for which he fought hard was that when a convict had served his period of sentence, and was again a free man, he was entitled "to be considered on a footing with every other man in the colony according to his rank in life and character." He appointed to the commission of the peace a clergyman who had been transported for suspected complicity in the Irish rebellion, and invited to his own table four or five "emancipists" who happened to be men of education and manners. But this policy gave deep offence to many settlers who had no black marks against their names, and who considered themselves as pertaining to a kind of moral aristocracy. The resentment was especially bitter among the old adherents of Bligh, who from the first had looked askance on his successor, and were not averse from fomenting a quarrel with him. In some instances the Governor's zeal for the liberal treatment of emancipists led him too far, and incurred the disfavour of the Secretary of State; and he became involved in quarrels with the judicial officers, who would not permit emancipist attorneys to practise before them. But there was so little that was liberal in spirit in these early days of New South Wales that, even when Macquarie's acts were marked by errors of discretion, it is good to recognise the sense of justice that prompted them.

The convict system was in full force for just over fifty years. From first to last, about 120,000 men and women were transported to Australia and Van Diemen's Land, of whom, in 1836, nearly 50,000 were living in the country. Half of these were "assigned" people: that is, they were living upon the properties of free settlers, to perform compulsory labour for them. The remainder were working for the Government in penal establishments or in "road gangs." The inhumane features of the system are exposed in the report of an English Parliamentary Committee of 1837–8; and they

* *A Colonial Autocracy*, by Marion Phillips. (London, 1909.)

are described with gaunt realism in a piece of fiction which has a backing of sober fidelity—Marcus Clarke's *For the Term of his Natural Life*.

The Parliamentary Committee recommended that no more convicts should be sent to Australia, and an Order in Council issued in 1840 directed that transportation should cease. But Van Diemen's Land continued to be used for the purpose, with consequences that soon became alarming. The dumping of 3,000 convicts per annum in an island, where the means of coping with the influx were inadequate, brought about a crisis, which British Ministers sought to mitigate by re-instituting transportation to the mainland under another name. The "conditional pardon system" was devised. Under it, a convicted person who had served a preliminary term in an English prison might be shipped to Australia, where he would be free, subject to the "condition" that he did not return to England during the remainder of the term of his sentence. Some convicts were sent to Victoria, as well as to New South Wales, under this system. But a vigorous and vociferous public opinion had by this time grown up in these colonies. The period had passed when they were content to have the contents of English gaols emptied at their doors. The people of Melbourne, in 1849, organized to resist the incursion, and threatened to prevent by force the landing of the "exiles." An equally strong feeling of resistance manifested itself in Sydney; and British Ministers were astonished to realize that, in a country originally colonized to carry out a transportation system, the first large question of public policy about which public opinion pronounced itself in emphatic terms was that transportation should cease. Governor Fitzroy yielded to the agitation, and the exiles—styled "Pentonvillains," after Pentonville prison wherein they served their probationary period—were sent on to Moreton Bay. Earl Grey, the responsible British Minister, very reluctantly gave way, and shortly afterwards the shipping of convicts to any part of the country except Van Diemen's Land and Western Australia ceased. The former colony was still used as a penal settlement until 1852, and signalized her deliverance (1856) by changing her name to Tasmania. Western Australia, being urgently in need of labour, gladly received convicts from 1843, and even protested against the discontinuance of the supply. She continued her policy long after the other Australian Colonies had freed themselves from what they termed "the convict taint." Her persistence, indeed, provoked much bitter feeling, and threats to boycott Western Australia were made by responsible statesmen in the eastern colonies. There is no doubt that the system did much to establish Western Australia, and her prosperity was well assured when, in 1868, transportation was finally discontinued.

5. Inland Exploration.

From the earliest period of settlement, the problem of the inland exploration of Australia obtruded itself as difficult and dangerous. For a quarter of a century after Sydney was founded, no practicable path was discovered across the mountain barrier that lay in the background. The Blue Mountains are not a very lofty range; they do not rise beyond 4,500 feet, but their tumbled formation made them a really formidable barricade, and they shut the little community at Port Jackson within an enclosure extending only about 40 miles from the sea. An escaped convict made his way inland

during Hunter's governorship, and several explorers endeavoured to find a pass. But it was not till 1813 that Gregory Blaxland, accompanied by Lawson and Wentworth, discovered a practicable track, and opened to occupation the richly-grassed Bathurst Plains.

Hardly any portion of the globe has presented so sullenly obstinate a face against the explorer as Australia has done; and there are few countries wherein gloomy predictions concerning the prospects of settlement have been so completely falsified. Immense stretches of territory which to-day are yielding an abundance of wealth to industry were originally condemned as wholly unfit for human habitation. The price of investigation has often been paid in suffering and death; and Australia is fully conscious of her obligation to a succession of hardy and courageous men who are as truly her heroes as are warriors to other peoples.

The first achievement of note in the story, after Blaxland's, is that of John Oxley, who in 1817–8 led two expeditions west and north, and came in touch with the complicated river system that feeds the Murray. Five years later he penetrated Queensland territory as far as Port Curtis, and prepared the way for the settlement which has grown into the city of Brisbane.

A very important inland journey was that of Hamilton Hume and William Hovell in 1824. They discovered and crossed the River Murray, the principal water-course in Australia, continued south, found the Ovens and the Goulburn, traversed a portion of the fertile western half of Victoria, and were the first Europeans to come upon Port Phillip from the landward. Allan Cunningham, the botanist, a *protégé* of Sir Joseph Banks, between 1817 and 1830 made a series of excursions into untraversed areas, discovering a practical pass to the Liverpool Plains (1818) and an easy route to the Darling Downs (1828). His botanical work was of the utmost importance, and his explorations won him a place among the most enterprising of Australian pioneers.

One of the greatest names in the story is that of Charles Sturt, a captain of the 39th regiment quartered in Sydney during the *régime* of Governor Darling. On his first journey, in 1828–9, he discovered the Darling River; and on a second journey, commenced in 1829, he took with him the timbers of an old whaleboat, nailed them together on the banks of the Murrumbidgee, descended the stream to its junction with the Murray, and floated down that great river until, after a voyage of 33 days, he heard "the distant thunder of the great Southern Ocean." He had floated into Lake Alexandrina, wherein the waters of the Murray disembogue. Severe hardships were endured on the return journey. Sturt's party had consumed their last morsel of food when relief came, and some of his men showed signs of insanity, from incessant toil and privations. Sturt himself was blinded for a time. This journey had more immediate consequences affecting the colony of South Australia than that of Hume and Hovell had upon the fortunes of Port Phillip; for his reports led to the founding of Adelaide.

Sturt's genius for exploration led him in 1844 to start from Adelaide to penetrate the interior of the continent. This he did in a summer of exceptional heat, maintaining a stubborn fight against thirst, hunger, scurvy, a pitiless sun, a blistered desert, and a pelting from blasts of hot fine sand.

He crossed Cooper's Creek, which he discovered and named, but broke down a few miles beyond it, and was carried back to Adelaide a stricken man. His work cost him his eye-sight, though he lived a quarter of a century after his last expedition. Sturt was described as being "brave as a paladin, gentle as a girl," and his achievements are, most worthily, ever "freshly remembered."*

Gippsland, the eastern wing of Victoria, was entered from New South Wales in 1839 by Angus McMillan, when searching for cattle pastures; and in 1840, a Polish man of science, Strzelecki, accompanied by two stock-raisers, Macarthur and Riley, also explored the same region. It was Strzelecki who suggested the use of the name Gippsland, in compliment to the Governor of New South Wales, and Australia's loftiest mountain, Kosciusko, bears the name of a Polish hero as a consequence of the travels of this investigator.

At about the same period, 1838, Edward John Eyre—a young cattle farmer of 25, who was afterwards (1865) to become Governor of Jamaica, and was unenviably famous in connexion with an insurrection there—indulged a taste for exploring by penetrating the unknown country beyond the limits of South Australian settlement. He found Lake Hindmarsh on one of these excursions. Ambitious to accomplish something memorable, Eyre led an expedition along the shores leading to the Great Australian Bight in 1839, and in 1840 decided to explore the interior of the continent to the north of Adelaide. He followed the line of the Flinders Range to Lake Torrens, and found a stretch of country so impregnated with salt that even rain water became brackish after lying a short while on the ground. After discovering Lake Eyre, the explorer, dissatisfied with his results, travelled down to the coast at Fowlers' Bay, where he established a camp. From this point, he resolved to pursue the coastline as far as King George's Sound, and, as the enterprise was full of peril, ordered his men to return to Adelaide, while he went on alone. But his overseer, Baxter, refused to leave him, and with this companion, and three young blacks, Eyre set out in 1841. He had some sheep and flour for subsistence. The food did not last long, and before it was entirely exhausted, two of the blacks proved treacherous, shot Baxter, and plundered the flour bags. Eyre and his one faithful black servant continued the journey, living on horse-flesh and quenching their thirst with dew collected on a sponge and squeezed into a pot. When at the extremity of endurance they sighted a French whaling ship, the *Mississippi*; but after receiving assistance the iron-willed explorer set out again, and reached his goal, King George's Sound, on 7th July, 1841.

The explorations of Sturt and Eyre had started from Adelaide. We return to the Sydney side to mention those of Thomas Mitchell and Ludwig Leichhardt. Mitchell was the Surveyor-General of New South Wales, and from 1831 had explored the interior from Sydney in search of good country for settlement. Some of his journeys were full of adventure, notably that of 1835, when Richard Cunningham, the brother of Allan Cunningham, was murdered by blacks. Mitchell's most memorable piece of work was his expedition to "Australia Felix," or Victoria, in 1836. He crossed the Murray and traversed the country westward of Hume and Hovell's track

* *The Life of Charles Sturt* by Mrs. Napier Sturt (1899), is an excellent biography.

of twelve years before. To his surprise, on reaching Portland Bay, he found the huts of white men on its shores, for the Hentys of Tasmania had already established a whaling station there, and had become the pioneer settlers of Victoria. Mitchell's last of many journeys was undertaken in 1845, when he set out to explore a route to the Gulf of Carpentaria. He did not succeed in his main object; but his glowing reports showed the value of the tableland of western Queensland, and had important consequences in stimulating settlement.

Leichhardt was a German man of science who was attracted to the problems pertaining to Australian inland exploration. His first important journey was in 1844, when he travelled from Sydney to Port Essington, on the north coast, arriving there nearly naked, and with rations reduced almost to the last crumb. He and his companions had lived partly on the flesh of flying foxes, and had found water by observing the flight of bronze-wing pigeons towards it. A second expedition was to the far western interior, 1846, and from his third, 1848, he never returned. He aimed at crossing the continent from east to west, from Moreton Bay to the Swan River. He certainly reached the Barcoo, where the letter "L" was found cut on a tree twenty years later; but exactly where he perished has never been ascertained. The fate of Ludwig Leichhardt is one of the unsolved mysteries of the history of Australian land exploration, as the fate of George Bass is an unsolved mystery pertaining to one of the country's maritime explorers. A. C. Gregory, who went out in search of Leichhardt, led expeditions in Northern Australia, and crossed the continent south-west to Adelaide in 1858.

John Macdouall Stuart, who had been with Sturt in 1844, made important journeys to the interior in 1858 and 1859, discovering a fertile and well-watered area west of Lake Eyre. His work was so useful that the South Australian Government, to stimulate him or others to further efforts, offered a reward of £2,000 to the first man who should cross the continent from south to north. Stuart started in 1860, and on 22nd April of that year penetrated to the very centre of Australia. He was not now in desert country, but found the area surrounding his Central Mount Stuart to be well-grassed, plentifully watered, and pleasant. But further on he was beaten by thirst, thick scrub, and troublesome aboriginals, and was compelled to return to Adelaide. In 1861 Stuart started again, and turned back; but in 1862 he made his way right across, and on 24th July "was delighted and gratified to behold the waters of the Indian Ocean in Van Diemen's Gulf." Stuart's journeys were of the greatest value in demonstrating that the interior of Australia was conquerable, and in revealing the excellent pasturage to be found in portions of the country.

Contemporary with Stuart's final journey, the sensational and dramatic expedition of Burke and Wills took place. It is perhaps the best remembered of all Australian inland explorations, because of the mystery and fatality attaching to it: though in truth the explorers whose achievements have already been mentioned, Hume, Mitchell, Sturt, Eyre, and Stuart, did greater things, and faced equally severe hardships, but "won through" by a more perfect bushcraft and finer qualities of leadership. The Burke and Wills expedition was organized in 1858, when a sum of about £10,000 was provided, partly by subscription, partly by the Victorian Parliament,

for the purpose of promoting an endeavour to cross Australia through the centre, from south to north. The command was entrusted to Richard O'Hara Burke, a police inspector well known to be a brave and intelligent man. The expedition was well equipped, and should have succeeded and returned in safety if Burke had exercised sound judgment. A depôt was established at Cooper's Creek, and from that point, in December, 1861, Burke, with Wills and two other men, determined to make a dash for the Gulf of Carpentaria. The party did reach the Flinders River, which flows into the Gulf, and were within two days' journey of the sea, but they were insufficiently provisioned, and had to return to Cooper's Creek. When they reached the depôt, after four and a half months' absence, they found that Brahe, the man whom Burke had left in charge, had left just seven hours before. The time he had been instructed to wait had passed, and he had resolved to go to Menindie, on the Darling, where the reserves of the expedition were based. He left some provisions in a hole in the ground, and cut the word "Dig" on the bark of a neighbouring tree. When Burke, Wills, and King—the fourth man had died on the journey—staggered into the Cooper's Creek depôt, their condition was desperate. They ate the provisions they found, and rested a couple of days, debating what course they should pursue. Burke, instead of following in Brahe's tracks, as Wills wanted to do, insisted on making for a cattle station at Mount Hopeless, 150 miles away. It was a fatal resolve. They killed their camels for their flesh, and crept forward on foot. When within 50 miles of Mount Hopeless Burke, not knowing how near he was, gave the order to turn back to Cooper's Creek. The pitiful story of the last days of weary, famished life suffered by the three is as intensely pathetic as anything in the history of exploration. Wills died first, in the hut at Cooper's Creek. Burke and King tried to find the encampment of some blacks who had helped their dead companion some time before. Burke broke down and died by the way; King lived with the blacks until he was rescued by A. W. Howitt, who had been sent out from Melbourne in charge of a relief expedition. He survived until 1872.

The tragedy of Burke and Wills does not end the story of Australian inland exploration, but may be taken to be the last sensational event in it. In Western Australia, the brothers John and Alexander Forrest did brave work. The former, after having in 1869 led an expedition in search of remains of Leichhardt, set off (1870) to examine the country which had been explored by Eyre, along the shores of the Bight. He directed attention to the well-grassed areas lying a few miles from the coast. In 1874 John Forrest traversed the country intervening between Western Australia and the settled portions of South Australia. Alexander Forrest in 1879 explored from the De Guy River, on the north-west shoulder of the continent, across to the Fitzroy, which flows from the Leopold Range to King Sound; followed the Fitzroy to its source, and then struck north-east to Port Darwin. His enterprise opened up 20,000,000 acres of good country, besides showing the way to the rich Kimberley Gold-fields.

The journeys of Ernest Giles and of Warburton, 1875–6, must be mentioned: and it should also be said that the several scientific expeditions of Baldwin Spencer to the interior, though undertaken primarily for purposes

of biological research, have been of the utmost value in a wider sense. They have enabled a trained observer to direct attention in a very striking way to aspects of the country not commonly indicated by explorers of the usual type.

6. Extension of Colonization.

Where the explorer pointed the way the pioneer colonist followed; but there was also, for an interesting period, another motive for extending occupation beyond the original confines. That was the threat of French rivalry. The fierce animosity, generated between England and France as a consequence of the revolutionary and Napoleonic wars, was not without advantageous results in Australia. It made the governing authorities anxious to establish settlements in unoccupied territory, for fear that the French should plant colonies there. There are no facts to show that the French Government proposed annexing a portion of Australia.* But it was firmly believed that they contemplated such a policy: and the belief was just as effectual in stimulating expansion as if positive evidence of aggression had been produced.

Immediately after the departure of Baudin's expedition from Port Jackson, Governor King caused two settlements to be planted in Tasmania: at Risdon, on the Derwent, in 1803, and at Port Dalrymple, on the Tamar, in 1804. The same fear of French occupation led the British Government to send out Lieutenant-Colonel Collins to establish a colony at Port Phillip in 1803 Collins, unfortunately, landed his 300 convicts on the sandy peninsula which divides the port from the ocean, and, quite naturally, formed an unfavorable opinion of its suitability. Consequently, the first Port Phillip settlement failed, and Collins' people were removed to the Derwent. Lieutenant Tuckey, who wrote an account of the experiment, observed, on leaving the port which is now the seat of the great city of Melbourne, "the kangaroo seems to reign undisturbed lord of the soil, a dominion which, by the evacuation of Port Phillip, he is likely to retain for ages." That was 109 years ago.

There were other French scares long after Napoleon had ceased from troubling. In 1825, it was rumoured that a French settlement was to be attempted at Westernport. Governor Darling despatched H.M.S. *Fly* and two brigs conveying troops with instructions to establish themselves. It was found that French ships had called at Westernport, then quite unoccupied, but no attempt whatever had been made to found a colony there, and, the fear of rivalry subsiding, the British packed up their apparatus and returned to Sydney.

A similar desire to frustrate foreign occupation in Western Australia had more enduring consequences. The French were again supposed to be moving; and in 1826 Major Lockyer, of the 39th regiment, was sent from Sydney in command of a detachment of troops and a party of convicts to occupy King George's Sound. This was the beginning of colonization in the western State; and even when a more determined attempt was made to found a settlement upon the beautiful Swan River, the British Government,

*Lord John Russell recorded (*Recollections and Suggestions*, 1875 p. 203) that while he was Colonial Secretary in the Melbourne Government 1839-41 "A gentleman attached to the French Government" called upon him and asked how much of Australia was claimed by Great Britain. He replied "the whole," and with that answer his visitor went away

"being anxious to anticipate any such measure by France," offered land at the rate of one acre for every eighteen pence taken out in cash or goods by immigrants. The first Governor of the western colony was Captain Stirling, R.N. The English promoters of the colony secured the emigration of 4,000 persons in the first four years (1829–31), with whom a fair start was made Perth being chosen as the centre.

The instructions to Governor Phillip, when the first colony was established at Port Jackson, directed him to occupy Norfolk Island, which lies in the latitude of the Queensland border, about 900 miles from the east coast, to "prevent it being occupied by the subjects of any other European power." Within a month, therefore, of the founding of Sydney, Phillip despatched Lieutenant King with a small party of officers and convicts to form a settlement. Two years later, Phillip, confronted by famine conditions, sent nearly 300 convicts to Norfolk Island, and by 1793 there were over a thousand people there. But the establishment was costly, and when it was determined to colonize Tasmania, the Norfolk Islanders were transferred to the Tamar and the Derwent. It was again used as a convict establishment at later dates, and has had an exciting and romantic history, compounded of insurrection, piracy, and shipwreck, as well as of curious phases of more peaceful colonizing. Many of the present inhabitants are descendants of Pitcairn Islanders, whose forefathers were associated with the famous *Bounty* mutiny.

South Australia is the only one of the six States of Australia that had no direct connexion with convictism. Transportation, indeed, was expressly debarred in the constituting statute. The colony was originally established to carry out a theory. Edward Gibbon Wakefield, who spent three years in Newgate for abducting a ward in Chancery, had leisure there to meditate on problems of colonization. Though he had never been in Australia, he published in 1829 a little book directing attention to what he believed to be the defects of the system followed in New South Wales. His *Letter from Sydney* was so bright and clever that it was generally believed to be the result of observations made and impressions formed on the spot. It attracted all the more attention from the efforts then being exerted to settle Western Australia on a plan promulgated by Thomas Peel. Wakefield's main point was that it was a mistake in policy to grant land in a new colony in large areas on cheap terms, but that it should be sold at "a sufficient price," and the proceeds devoted to bringing out families of settlers. In 1830 the National Colonization Society was founded in London to carry out Wakefield's ideas, and in 1834 Parliament passed an Act establishing the colony of South Australia. A board of eight commissioners was appointed to manage affairs, a Resident Commissioner being on the spot, and his colleagues remaining in London; but the Crown also appointed a Governor, Sir John Hindmarsh. Eight vessels laden with immigrants arrived during 1836 at Kangaroo Island, where it was at first proposed to locate the colony. The place was deemed unsuitable, and Colonel Light, the Surveyor-General, chose a site on the east side of St. Vincent's Gulf where the city of Adelaide has been built.

The Wakefield theory did not work; nor did the system of control. Hindmarsh quarrelled with the Resident Commissioner, and both were recalled. Colonel Gawler, who succeeded, plunged the settlement into

financial embarrassments; and it remained for the third Governor, George Grey (1841–5), to apply good sense and strong statesmanship to the situation, and to place South Australia upon a sound, stable, and progressive footing.

Queensland was originally occupied as an offshoot from Port Jackson. Governor Brisbane desired to relieve the pressure upon Sydney by extending settlement. Lord Hobart had said twenty years before, "if you continually send thieves to one place it must in time be supersaturated. Sydney now, I think, is completely saturated. We must let it rest and purify for a few years, till it begins to be in a condition again to receive." It had not been allowed to sweeten by rest, and Brisbane had instructed Oxley, the explorer, in 1822 to look for a good place for an overflow-settlement. Oxley considered the shores of Moreton Bay offered an excellent situation; and in 1824 the foundations of the city of Brisbane were laid. The Governor intended that the new station should be reserved for offenders who committed crimes after transportation. "According to the nature of the offence are they punished," he explained. "Those guilty of the least are sent to Port Macquarie (on the west coast of Tasmania), those of a graver nature to Moreton Bay, and those of the deepest dye to Norfolk Island." In 1849, when both Victoria and New South Wales refused to receive any more "exiles," they were sent on to Brisbane; but transportation to this settlement ceased when the rest of eastern Australia was freed from it.

The colonization of Victoria arose from totally different causes than those which operated in any other State. It has been shown that Tasmania and Queensland were chosen as fields for the extension of the convict system, that sites in Western and South Australia were selected to try the efficacy of theories, and that a jealous fear of French occupation prompted early settlements in Tasmania, Western Australia, and Victoria. The two attempts made to found colonies in the latter State, in 1803 and 1825, were total failures. When effective occupation did ensue, it occurred in quite a natural way. The explorations of Hume and Hovell, and of Mitchell, demonstrated that immense areas of valuable pasture land lay south of the Murray; the Henty Brothers from Tasmania in 1836 settled at Portland, brought sheep and cattle with them, and commenced cultivation for the provisioning of their whaling boats; and the news of the kind of country they had found induced other Tasmanians to follow. The Government did not promote occupation; enterprising men sought out lands for their own advantage. There was no theoretical scheme to test; knowledge of good land and the pursuit of profit furnished the main motives. In May, 1835, John Batman, who had formed an association in Tasmania for the utilization of Port Phillip lands, sailed over and examined the country in the Geelong district. He was well satisfied with what he saw. He took his boat up the bay, anchored at the mouth of the River Yarra, and set off on foot to explore. On this journey he fell in with aboriginals, and made with their chiefs the famous bargain by which he supposed himself to have purchased about 600,000 acres of land, including the whole of the present site of Melbourne, for a trifling yearly tribute and a present of blankets, looking-glasses, knives, scissors, and handkerchiefs. The Government naturally declined to ratify a "treaty" so made with savages who had not the faintest notion of what they were doing; but there is every reason to believe that Batman acted in good faith. The original

document, which is drawn up in what a high authority allows to be "English legal form," and purports to bear the "marks" of the chiefs, is still preserved, and is one of the curiosities of the history of colonization.

Batman had a rival in John Pascoe Fawkner, who came over from Tasmania in August, 1835, and whose activity did much to advance the progress of the little colony in its infant years. Early in 1836 many more pastoralists came over from Tasmania. In May of that year there were 177 people living on the site of Melbourne, 31 of whom petitioned Governor Sir Richard Bourke to send over a magistrate to regulate affairs. In September, Bourke despatched Captain William Lonsdale to take charge. Batman had chosen the site for a "village" on the banks of the Yarra. Lonsdale confirmed the choice, and in March, 1837, that village received from Bourke, who paid a visit of inspection to it, the name of Melbourne.

7. Progress of Settlement.

A thorough study of the history of land settlement in Australia has not yet been made. The student who will some day undertake the task will have to master a bewildering complication of experiments, administrative and legislative, and will have to elucidate a baffling variety of devices, theories, ingenious means of defeating virtuous intentions, and frequent changes of policy to adapt the law to rapid changes in social structure. He will have to begin with a study of the very first principles affecting the rights of the Crown to control the disposition of unoccupied land. The theory that the Crown is the absolute owner of all land is described by an indubitable authority as "the driest of legal fictions, a fiction, moreover, which, unlike most legal fictions, never corresponded with fact."* Yet except for the practical application of this theory as a fundamental principle, the settlement of the colonies could not have been controlled. Without it, the first comers would have seized all the good land, and nothing short of revolution could have dispossessed them. "It may seem almost incredible," says the authority cited, "that a question of such magnitude should be settled by the revival of a purely technical and antiquarian fiction." But if such a principle had not existed, in however shadowy a form, it would have been necessary to create one of the kind. Even as things occurred, many first-comers acquired enormous areas on such easy terms that the expansion of settlement has been hindered.

The earliest settlements out of Sydney were established on the Parramatta, Hawkesbury, and St. George's Rivers. These were founded within the first ten years, when endeavours were being made to render Port Jackson self-supporting. The land grants made were comparatively small, and terms were easy both to free men and emancipists. When the Blue Mountains were crossed in 1813, and the rich pastures beyond came within the scope of the settlers' enterprise, new problems arose. The prospect seemed boundless. There were millions and millions of acres stretching away to regions as yet unexplored. Governor Macquarie wished to restrain the limits of occupation, and would not make large grants. The British Government also considered that the dispersal of settlers over enormous stretches of

* Jenks, *History of the Australasian Colonies*, page 59.

country unwise. But the rapid development of the wool industry after Macarthur introduced the Merino sheep and demonstrated the peculiar adaptability of Australia for the production of fine fleeces, impelled men to go far afield, where their flocks could multiply. Hence arose the squatting system. An owner of sheep would set out with his sheep and his drovers, and would "squat" upon an area of unoccupied land, which, being an experienced man, he would choose with skilful discernment. Then he would erect huts, would live there with his assistants, and would endeavour to make a fortune out of wool as rapidly as possible. The early squatters had no title to the land they occupied. They took it because it was available, and it was for the Government to deal with them as it pleased. Legally, by the application of the "legal fiction" above mentioned, they were trespassers. Actually they were men of courage and enterprise, who made the best use then possible of land which was lying idle. It remained for Governor Bourke, in 1836, to deal in a practical way with the problem created by extensive squatting. He divided the country which the squatters had occupied into pastoral districts, and issued grazing licences to occupiers for low fees. The licences created no ownership, but they gave the squatters security of tenure for defined areas, and for specified periods.

It was Governor Bourke, too, who first (1832) adopted the measure of appropriating part of the proceeds from the sale of land to bring immigrants to Australia; and this policy was in 1840 laid down as a sound one by a Board of Colonial Land and Emigration Commissioners, appointed in London to advise the Secretary of State. By this time, the advantages that Australia offered to agriculturists were becoming well recognised in Great Britain. The opening up of Port Phillip and the establishment of colonies in South Australia and Western Australia likewise attracted settlement. One pound per acre was stipulated as a common price for the sale of land to settlers. A good number of young men possessed of capital sought avenues for fortune in the new country, and many founded families which to-day are, as Hamlet said of Osric, "spacious in the possession of dirt." During the thirties and the early forties, the flow of immigration—amounting to 10,000 persons per annum to New South Wales alone, in some years—effected a great change in the general character of the country. A policy of assisted immigration hastened expansion. It was during this period that there grew up that marked aversion to the continuation of convictism which has already been pointed out. The growth of the towns facilitated the consolidation and emphatic expression of opinion. The new-comers had changed their clime with a view to make homes for themselves and their posterity, and the spirit of nation-makers was within them.

The process of parcelling out the land in large areas, principally for sheep-raising, continued till after the decline of the first prodigal gold yield, and the consequent diversion of the energies of some thousands of men from digging. Statesmen were now compelled to find means of settling farmers on smaller blocks. Cultivation on an extended scale became requisite. Hence arose a struggle with the powerful squatting interest which the conditions of previous decades had created. The squatters did not want settlement. They were satisfied with convictism. Indeed, the representations of the squatters, who needed labour for their runs, were partly responsible for the creation

of the "conditional pardon system." for Gladstone, who was Secretary of State for the Colonies when the system was inaugurated, was a partner in a Victorian station property, and was well aware of the opinion of the large land-owners. Some of them spoke contemptuously of free immigration "We urgently need labour, and would rather have the pick of the gaols than the refuse of workhouses," said the squatters of Moreton Bay in a document in 1850. The free immigrants were not "the refuse of the workhouses," but they were largely farmers, and the squatters did not approve of the cultivation of small areas. Ridicule was poured on the very idea of profitable cultivation in parts of the country—the Darling Downs for example—where to-day there are thousands of prosperous settlers.

The methods employed to secure room for settlers have been various, and the enactments embodying them are much too complicated for exposition within the limits of an historical summary. They began with the device of "selection before survey," under which a person desiring to settle and cultivate could enter upon a "run" leased from the Crown by a squatter, mark off an area for himself, erect a dwelling upon it, and make it his own by paying £1 per acre for it by easy instalments. The system produced a crop of evils, and was not very effectual in attaining the object in view. It led, on the one hand, to the "peacocking" of properties, often not for purposes of genuine occupation, but to induce the squatter to buy out the intruder—that is to say, it conduced to a species of blackmailing; and, on the other hand, it led to "dummying," squatters arranging with persons acting in collusion with them to select the best parts of a leased run, and so keep out strangers. The Duffy Land Act, passed in Victoria in 1862, though designed to promote settlement, also led to the augmentation rather than the dividing of big estates. In the nineties the land settlement problem became more urgent. Improved methods of dairying, the development of a large butter export trade, the profitable extension of orchard culture, the application of machinery to wheat production—these factors, together with the desire of thousands of native-born farmers' sons to make homes for themselves, and the augmentation of the pressure of demand for land by immigrants, compelled new policies to be inaugurated. Governments, in order to settle a rural population, began to repurchase from owners at high prices large estates which had been acquired from the Crown at low prices. These areas were subdivided and re-sold to farmers on easy terms. A more radical method of attaining the same end was a tax on the unimproved value of land, passed by the Federal Parliament, 1910. The tax, though an important revenue-producing agency, was primarily designed to compel large land-owners either to sell or to put their holdings to the most productive use.

One of the beneficent results of Australian settlement, not only to this country, but to the colonization generally, was the devising of a cheap and simple system of land transfer. The Torrens Act was passed by the South Australian Parliament in 1858. Its author, Robert Torrens, was not a lawyer, and his efforts were discouraged by the profession, whose members clung fondly to the old complicated system which required each transfer of real property to be accompanied by title deeds recapitulating the previous owners. Torrens devised the method of registration of lands in a public office, where

the ownership of any piece of property could be determined at a glance. His scheme met with ridicule and strenuous opposition. Experienced lawyers declared it to be unworkable. But the Real Property Act of Torrens was carried, and he was appointed to superintend its working. It proved to be so safe and successful in South Australia that the other colonies soon adopted it; and the distinguished French historian of modern colonization, Leroy-Beaulieu, declares that a system of the kind is essential to the well-being of any colony.*

Two facts stand out, in connexion with the extension of settlement in recent years. One is the appreciation of the importance of irrigation in Australian development. The second is the discovery of means of profitably utilizing lands which were long considered to be of little or no cultivable value. Vast areas in South Australia and Victoria, once believed to be beyond subjugation by the plough, are now yielding millions of bushels of wheat per annum. American "dry farming" methods have been adapted to Australian conditions with eminently successful results. Only lately have the possibilities of irrigation been appreciated, and the country is hardly more than at the beginning of a new era in this regard. Mr. Deakin, in the late eighties, inaugurated an irrigation policy in Victoria, and it stands to the credit of his statesmanship that he saw, and strove to make his countrymen realize, the importance of the scientific application of water to the soil. When Mr. Deakin travelled in the irrigated areas of America and India, wrote his *Irrigated India*, and inaugurated his policy, farmers were not quick to remodel their methods. But a new generation, taught by zealous experts, shows a livelier sense of what is to be gained by the co-operation of the irrigation engineer.

8. The Gold Discoveries.

The great era of gold discovery in Australia dates from 1851, but nearly twenty years before that time particles had been found in the neighbourhood of Bathurst. In 1839, Count Strzelecki detected traces of gold amongst decomposed iron ore, and informed Governor Gipps, who was not gratified by the news, thinking that if it became generally known the difficulty of restraining the convict population would be great. But when Strzelecki reached England, his geological specimens and maps were examined by Sir Roderick Murchison, who, in a paper read before the Royal Geological Society, pointed out the resemblance between the mountain region where the Polish count had travelled, and the gold-bearing Ural mountains. Murchison even wrote to the Secretary of State, Earl Grey, predicting that valuable finds of gold would be made in Australia; but no notice was taken of his letter. In 1848, a man named Smith found a nugget embedded in quartz near Berrima, in the Blue Mountains, but the Government would not follow up the discovery, for fear "of agitating the public mind by ordering geological investigations."

Just as an analogy with the Urals impelled Sir Roderick Murchison to prophesy, so a resemblance between Australian conditions and those of the Californian gold-fields convinced Edward Hargreaves that gold would be

* Leroy-Beaulieu, *De la Colonisation chez les Peuples Modernes* II, 589, where particular attention is devoted to the subject

found in the Bathurst district of New South Wales. He had been a squatter there, and had gone to California to seek fortune when the news of the gold discoveries came in 1849. He soon convinced himself that the country with which he had been familiar in Australia was so like that which he saw in America that it ought to be similarly auriferous; and he returned in 1850 to investigate. His reasoning was justified. He washed gravel in the bed of the Summerhill Creek, and found a small nugget at the first trial. Each succeeding dish of earth dug out produced gold. When Hargreaves returned to Sydney and disclosed his news to the Government, the exciting gold-rushes of the fifties commenced, and Australia entered upon a new phase of her history.

There was at the same time a belief that gold would be found in rich quantities in Victoria. As early as 1849, a shepherd youth named Chapman sold 22 ounces in Melbourne. He had found it in a gully in the hills of the western half of the colony, while looking after his sheep. Other bushmen occasionally brought small quantities of gold into the city, and there was a general expectation that important discoveries would be made. When the success of Hargreaves north of the Murray became known in Melbourne, interest in the subject quickened, and a reward was offered to any person who should be the means of making known a gold mine within 200 miles of the city. Valuable finds were made in several parts of the country at about the same time; but the sensational development—that which was noised all over the world, and attracted thousands of the young and enterprising of all nations—was Hiscocks' discovery of gold at Buninyong, Ballarat, in August, 1851. Immediately after, in the same gully, a party of men washed out 4½ ounces from the surface earth in two hours, and on the following day obtained 30 ounces. Startling successes of this kind soon became common, and fabulous fortunes seemed to be within the grasp of those who could strike a good patch. The fame of Ballarat became world-wide. Ibsen, writing his poetical play *Love's Comedy*, in Norway, used the name in an image for vaulting ambition: an end "worth the leaping for" was "a Ballarat beyond the desert sands."

Many fortunes were made; many startling finds occurred. Dr. Kerr, guided by an aboriginal employé, found a huge block of gold weighing a hundredweight, embedded in a mass of quartz, on the Meroo Creek, in the Bathurst district. It was worth about £4,000. A Melbourne publican found a nugget weighing 7 lbs. while amusing himself by poking about with a pick at Black Hill. A ship's captain and seven sailors who tramped to Ballarat from Melbourne obtained nearly £3,500 worth of gold in three weeks, after which they went back to their ship and sailed in her home to England. In Canadian Gully, Ballarat, six nuggets were found in two months weighing in the aggregate about 390 lbs. Of Bendigo, a digger wrote, "You could see the gold shining in the heaps of dirt, and every man sat on his heap all night with a pistol or some weapon in his hand." It was a glittering period: yet a thoughtful Australian statesman, the late Sir Henry Wrixon, on one occasion ventured the opinion that on the whole the Australian gold-fields had doubtfully been of economic advantage to the country. He argued that the capital and energy put into gold mining had probably exceeded the value of the product, and that the same capital and energy applied to other

industries would have yielded a larger return. An historian whose opinions are always well weighed expresses the same view: "It is doubtful whether, on the whole, the gold mining industry was in itself profitable, whether as much money has not been spent, in the aggregate, on winning the gold, as has been made out of the yield."* There is probably much truth in the point; but, on the other hand, the gold-fields served Australia well in attracting to the country many thousands of men in the prime of life, a large proportion of whom remained. The political consequences were also, as pointed out below, of very great importance.

Much has been written of the wild life of the diggings, and some of the fiction intended to illustrate it is probably no more highly coloured than is justified by the facts. Stories like Rolf Boldrewood's *Miner's Right* and *Nevermore*, by an author who lived through the events whereof he writes, are full of the real atmosphere of a turbulent time. The administrative difficulties were so novel, the influx of population was so large, that authority was not a little bewildered. One serious struggle between law and disorder occurred. There was a threat of riot on the Turon, and an outbreak of bushranging originated from the presence of so many ex-convicts amongst so many opportunities for plunder. But the mass of the diggers were orderly, industrious men, whose inclination was to co-operate in maintaining good government. The tactless handling of questions at issue, rather than a lawless disposition on the part of the miners, produced the Eureka Stockade incident.

There was nothing unreasonable in the imposition by the Government of Victoria of a tax on the gold produced. The expenses of administration had to be defrayed from some source, and the many thousands of pounds worth of gold being obtained constituted a fund upon which Latrobe, the Lieutenant-Governor, deemed it equitable to levy. But the method chosen was unfortunate, and the means of collection proved to be irritating as a rule, and grossly unjust in many instances. Latrobe would have preferred a tax on gold exported. That would have ensured that only the successful diggers would pay, and that they would be taxed according to their good fortune. But his Legislative Council was not favorable to this mode, and the example of New South Wales was followed, in the imposition (1851) of a licence-fee of 30s. per month on every miner. It was inequitable, because it hit the miner with a poor claim as hard as the man who was obtaining plenty of gold. But it was made an instrument of gross tyranny in operation. A person could be arrested at the instance of an informer, if found upon the diggings without a licence actually in his possession, and the fact that the informer was entitled to one-half the penalty recovered, which might be £5 for a first offence, conduced to the arrest of wholly innocent persons, who had no direct connexion with mining, and to the constant irritation, and even persecution, of properly licensed men. Moreover, the miners protested that they had no representation in the Legislative Council, and that taxation without representation was un-British.

Latrobe, severely harassed by inadequate revenues, proposed to increase the licence-fee to £3 per month, but the outcry was so strong that he desisted.

* Jose, *History of Australasia*, page 232.

In 1853 it was reduced to £1 per month, but the evils of the system of collection were not amended. In 1854 Sir Charles Hotham succeeded to the charge of the Government of Victoria, and the mining population hoped for reform. But they were severely disappointed. Hotham, faced by increasing gold-fields expenditure, and a depleted treasury, assumed a stiff attitude, and ordered the police to prosecute the collection of licence-fees with greater diligence. The extremely harsh conduct of the police, and the gravely defective administration of justice, aggravated the prevalent discontent. At Ballarat, the intense feeling was brushed up to a crisis by a riot which occurred in October, 1854, about the murder of a miner named Scobie, at an hotel of ill-repute, kept by one Bentley, an ex-convict. The latter was accused of the crime, but was acquitted at the instance of the magistrate, Dewes. There was good reason for suspecting the good faith of Dewes, and public indignation was strong. A public meeting was held, and while it was in progress a detachment of police was sent to protect Bentley's hotel. It was believed that the police intended to disperse the meeting. At once the anger of the crowd, about 8,000 strong, was directed against the very unpopular constabulary. Some stones were thrown, the windows of the hotel were smashed, and finally a fire was set to the building, and it was burnt to the ground. Three men were arrested, and the diggers subscribed bail money for them. Meanwhile a strong agitation against the licence-fees and the police policy was maintained. The movement was connected with that for the release of the alleged rioters and with the insistent demand of "no taxation without representation." The Reform League which was formed promoted a meeting at which licences were publicly burnt. On 28th November, a military detachment sent up from Melbourne was attacked on the road, when several troopers were wounded and a drummer boy killed. Some of the leaders of the league were foreigners; many were fire-brands, who talked wildly of upsetting the Government and establishing a republic. They even produced a flag, bearing the device of the Southern Cross on a blue ground, which was to float over the seat of the new order they intended to establish. They constructed a stockade flanking the road to Melbourne, about a mile from Ballarat, intending by its means to block the advance of more troops who were understood to be on their way up.

These preparations were rudely shattered by the prompt action of Captain Thomas, of the 40th regiment, who was in command of the military already on the field. On the morning of 3rd December he led an assault upon the stockade, attacking it from the rear with a force of not quite 300 troops and police. In about twenty minutes after his bugle rang out for the assault the "rebellion" was suppressed. An officer was killed, together with four privates, and about a dozen of the storming party were wounded. On the other side, fully 30 were killed, many were wounded, and about 130 prisoners were taken. Only one "rebel" was convicted, and he was the editor of the *Ballarat Times*, but he was liberated on his own recognisances. A negro was tried for treason and acquitted; and the Crown did not succeed in securing a conviction in any case. Peter Lalor, one of the ringleaders, afterwards (1880) became Speaker of the Victorian Legislative Assembly, and was a conspicuously able and conscientious man. The stockade incident effectually cleared the air, and brought about reforms which enabled gold mining to be

conducted henceforth as an ordinary peaceful industry. It forms a dramatic climax to the roaring digging days.*

Every State has had its gold rushes, but the opportunities for the making of many fortunes by men with little capital have never been so plentiful as in New South Wales and Victoria in the fifties. In Queensland, the most important discovery was the Mount Morgan mine, which made its purchasers millionaires. It was bought for £640 in 1886, and yielded £4,500,000 in ten years. In Western Australia the Kimberley Gold-field was opened up in 1887, and in the early nineties came the amazing discoveries of the Coolgardie and Kalgoorlie district. Large cities sprang up where once had been desert, and an enormous influx of male population completely changed the political complexion of the country. The great silver mines of Broken Hill also made huge fortunes for their proprietors. An example is that of Mr. George McCulloch, who was a sheep-farmer in the neighbourhood of the hill, which was found to be a mass of ore. He was one of the original owners, and with the great fortune amassed from the mines became a prominent collector of works of art in England. He died in 1908. Scarcely less important than the mines of precious metals have been the copper mines of the Burra (South Australia) and Mount Lyell (Tasmania), and the tin mines of Mount Bischoff. Coal mining, dating from the last years of the eighteenth century in New South Wales, is now extended to Victoria, Queensland, and Western Australia.

9. Constitutional Government.

It was inevitable that political tendencies in Australia should develop in a democratic direction; but the particular impetus given to the movement was affected in an important degree by the character of the population that flocked to the gold-fields in the fifties. Just before the great discoveries were made at Ballarat, Bendigo, on the Turon, and elsewhere, Europe had been seething with political discontent. The Chartist movement in England apparently collapsed in 1848, but the reforms demanded by the Chartists were still advocated by radical thinkers. The Irish evictions of 1847 and Smith O'Brien's "rebellion" of 1848 caused thousands of Irishmen to emigrate. The French Revolution of 1848, which overturned the Orleans monarchy, was flushed with the socialistic ideas of Louis Blanc. There were revolutionary outbreaks in Germany, a conference of Liberal leaders at Heidelberg demanded popular reforms, riots in Berlin frightened Frederich William IV., and a Radical party was clamorous in the *Vorparlament* of Frankfort. There was insurrection and a demand for manhood suffrage in Austria, the ideas of Mazzini evoked a national and democratic movement in Italy, and the same spirit was strongly manifested in Switzerland and Poland. The gold-fields populations of Australia were extraordinarily cosmopolitan; and, from whatever country the immigrants came, their political opinions were bound to be coloured by the movements of 1848. Many were political refugees; thousands shared the convictions of the English Chartists.

* The Eureka Stockade incident is still regarded, especially by those connected with mining, as a phase in a struggle for liberty, and the association of a relative with it is considered a matter of pride. Thus, on 2nd October, 1913, we find Senator Bakhap (Tasmania), in a speech in the Senate (Commonwealth *Parliamentary Debates*, 1913, p. 1734) making it a proud boast that "I have a claim, by virtue of blood and lineal descent, to speak feelingly in regard to fighting for the defence of the liberties of Australia. A very close maternal relative of mine was the very first man to be killed at the fight at Eureka Stockade"

Now, the demand for constitutional government in Australia was not in itself necessarily of an ultra-democratic character. The most prominent name in the history of the movement is that of W. C. Wentworth, and he expressly disclaimed any leanings in the direction of democracy The report of the Legislative Council of New South Wales drafted by him in 1854 declared that the advocates of constitutional government had "no wish to sow the seeds of a future democracy." What they desired was the establishment in Australia of such free institutions as are most characteristic of British principles of government—trial by jury, no taxation without representation, freedom of the press, and so forth. There was even a proposition to form an hereditary order of Australian baronets who should be in the Legislative Councils very much what peers are in the House of Lords in England: a disaster from which the country was happily saved by sanity and a sense of humour.

In the beginning the government of Australia was autocratic. The rule of the early administrators was subject only to the rather slack supervision of the Secretary of State. A Governor might consult his principal officials on matters of policy affecting their departments, but he need not. After about 1820, personal rule was modified. Governors were expected to take counsel with their officers. In 1825, a Legislative Council was established to assist in the making of ordinances. Its members were appointed by the Colonial Office: but it was not permitted to enforce any ordinance unless the Chief Justice certified that it was consistent with the laws of England "so far as the circumstances of the Colony will admit" The powers and size of the Council were extended in 1828, when the veto of the Governor and the Chief Justice were removed, and financial control was intrusted to it. In 1842, a decisive step forward was taken, when a Legislative Council was established consisting of 36 members, only twelve of whom were nominated by the Crown, the remainder being elected by those of the people who held freehold estate to the value of £200 or occupied premises with a rental of over £20 per annum. The Port Phillip District—for the separate Colony of Victoria had not yet been formed—was represented by six members upon this Council. Wentworth was also an elected member of it, and Robert Lowe was a nominated member—the Robert Lowe who was afterwards (1868) to become Chancellor of the Exchequer in the first Gladstone Cabinet and the Lord Sherbrooke of later days.

The Constitution of 1842 provided a satisfactory system of government for the time, and enabled public opinion to be fairly well represented. Tasmania (still known as Van Diemen's Land) had since 1823 been governed by a Lieutenant-Governor with a nominated Legislative Council of its own, and a similar system was in operation in South Australia and Western Australia.

Evidence that this method of government was being outgrown became apparent when a demand for separation grew in Port Phillip. Dissatisfaction arose from the spending of the proceeds of Port Phillip lands outside the district. The rapid growth of Melbourne, and the inconvenience of having affairs regulated from a centre 600 miles away, at a time when there was, of course, no railway connexion, gave impetus to the movement.

In order to call attention to the situation in a striking way, the Melbourne people in 1848 elected Earl Grey, the Secretary of State, as one of their representatives on the Council. The move was more than a jest. It was intended to stir the British Government to grant separation; and it succeeded. In 1850 a new Australian Government Act was passed; and on 1st July, 1851, Victoria was proclaimed a separate Colony. The name was recommended by the Committee appointed by the Secretary of State for the consideration of matters "relating to trade and foreign plantations," in 1849, and who advised the Queen to "be graciously pleased to confer the name of Victoria" on the new province. Both its northern boundary, the line of the Murray, and its western boundary, dividing it from South Australia, have since been the subject of dispute, and, in the latter instance, of a lawsuit. Under the new Act, the system of government which had for eight years prevailed in New South Wales was extended to Victoria, South Australia, and Tasmania. It is interesting to notice that, just as Robert Lowe was a member of the first Council in New South Wales, so H. C. E. Childers became a member of the first Victorian Council; both, at later dates, having been Chancellors of the Exchequer in England. Queensland did not become a separate Colony till 1859, when the form of government had been altered. Western Australia remained under the rule of a Governor and a Council of ten, none of them elected, till 1870, when the Council was enlarged. In 1890 responsible government was instituted.

A section of the Act of 1850 enabled the Legislative Councils of the Colonies to frame new Constitutions, which were not to be put in operation till the assent of the Imperial Government had been obtained. Public opinion on political concerns ripened very rapidly as the gold-lure attracted population, the towns grew, and newspapers were established. Political issues were keenly debated. Constitutional questions were discussed. People thought that the time had come to discard the old Legislative Council method, and to set up Parliaments modelled on the British pattern. Thus by 1854 the four Colonies had devised new Constitutions for themselves. Each Colony chose to have a Legislature consisting of two Houses. With respect to the Lower House, the Legislative Assembly, South Australia gave the franchise to every male over the age of 21 whose name had been six months on an electoral roll. New South Wales, Victoria, and Tasmania stipulated a small property qualification. The constitution of the Upper Houses, or Legislative Councils, differed very much. New South Wales preferred a nominee Council. Victoria, South Australia, and Tasmania chose to have elected Councils, insisting, however, on a relatively high property or educational or professional qualification. The Councils to-day remain substantially as they were constituted over half-a-century ago, except in the case of Victoria, where there has been a reduction of the property qualification of members. Queensland has followed the lead of New South Wales in having a nominee Council, but Western Australia decided for an elected body. To-day, payment of members of Legislative Assemblies prevails in all States: women are enfranchised in all States; the normal duration of a Legislative Assembly is three years in all States. The Executive in all States is framed on the British model. It is responsible to the Lower House of the Legislature, which, also, has paramount authority in matters of finance.

The working of representative government in Australia has conduced to some peculiarly interesting crises. There was a dead-lock between the two Houses of the Legislature in New South Wales in 1861. The Government of the day succeeded in passing through the Legislative Assembly a Land Bill intended to promote the acquisition of farms by men of small means. The squatters, who were powerful in the Legislative Council, did not favour the proposal. They rejected the Bill. The Premier, Mr. Charles Cowper, thereupon advised the Governor, Sir John Young, to appoint 21 new members to the Council. It was the device threatened in England in 1911 to overcome the reluctance of the House of Lords to pass the Parliament Bill. The Governor accepted the advice, and 21 supporters of the Land Bill were appointed. But when they attended to be sworn in, the President of the Council and a majority of the members rose from their seats and walked out, so that the sitting lapsed. A little later Wentworth —who had been in England—accepted the Presidency, a new Council was appointed, and the Bill was passed. It was the measure which introduced the "selection before survey" system. Sir John Young was blamed by the Colonial Office for appointing the "swamping" 21 councillors.

A crisis of extraordinary bitterness occurred in Victoria in 1865. A strong protectionist party had grown up, largely in consequence of the advocacy of David Syme and the *Age* newspaper. A Government headed by James McCulloch introduced a protective Tariff, which was passed by the Legislative Assembly. The Council, as was well-known, intended to reject the measure. Being an elected body, it was impossible to secure a majority by nominating fresh members. But the Council could not, under the Constitution, amend an Appropriation Bill. McCulloch therefore resorted to the expedient of "tacking" the Tariff on to the Bill providing for the ordinary annual services of government. The Council had either to accept the whole Bill, including the nauseous Tariff, or reject it, and thereby deprive the Government of the means of paying the salaries of the public service, the accounts of contractors, and other obligations awaiting discharge. The Council accepted the challenge and rejected the Bill. McCulloch, fertile in devices, went on collecting revenue under a Tariff which Parliament had not passed, borrowed money from the London Bank of Australia for meeting the immediate needs of the Government, and arranged with the bank to sue for the amount. Judgment was allowed to go without dispute, whereupon the Governor, Sir Charles Darling, issued a warrant for the payment of the money out of the revenue. This devious method was followed for four months, when McCulloch, to relieve the situation, persuaded the Assembly to send up a Tariff Bill to the Council free from "tacking" to an Appropriation Bill. But the Council rejected the measure even in this form. After a general election, which returned a powerful protectionist majority to the Lower House, they rejected it again. The Assembly pledged itself to support no Ministry that did not put forward a protectionist Tariff, and again there was a dead-lock. This time the Council gave way. The Tariff was sent up for the fourth time, there was a conference between the two Houses, a few concessions were made, and the protective policy became statutory in April, 1866.

Immediately afterwards another crisis arose. Sir Charles Darling was recalled by the Colonial Office on account of the part he had played in the events just chronicled. The Legislative Assembly, holding that he had acted constitutionally in following the advice of his Ministers, voted a grant of £20,000 to Lady Darling, and an address to Sir Charles thanking him for his services. The Council rejected the grant proposed. A dissolution ensued, and McCulloch's party was returned by an overwhelming majority. But the new Governor, Manners-Sutton, acting on instructions from the Colonial Office, sought to impede the carrying out of the will of the popular party, and a period of excitement and complication followed, the like of which has no parallel in Australian history. The Governor kept in office a Ministry which had no majority in Parliament, and which could not even obtain supply. The extraordinary situation was ended by the Colonial Office deciding to grant Darling a pension of £1,000 a year, and by the intimation that in these circumstances Lady Darling could not accept the £20,000 which the Legislative Assembly desired to vote for her.

Yet another constitutional crisis occurred in Victoria in 1877, over the question of the payment of members of Parliament. The Government of Graham Berry secured the passage of a Bill by the Assembly, but the Council rejected it. Thereupon the measure was "tacked" to the Appropriation Bill, which was laid aside by the Council. Berry dealt with the situation resolutely. Deprived of legal means of financing the operations of government, he dismissed hundreds of public servants. The Governor, Sir George Bowen, acting on the advice of Ministers, signed warrants enabling revenue to be expended without parliamentary sanction. Finally the Council yielded to the force of public opinion, and passed the Payment of Members Bill, which was sent up apart from the Appropriation Bill. Berry also induced the Council to pass a measure reforming itself, reducing the property qualification of its members from £5,000 to one of a clear annual value of £100, and the term of service from ten years to six.

The memory of these prolonged and bitter struggles between branches of the Legislature was carefully regarded when the Commonwealth Constitution was being drafted; and provisions were expressly inserted therein for the prevention of "tacking," and prescribing a course of procedure to remedy dead-locks. There have been difficulties in other States than Victoria; in South Australia disputes have frequently occurred; but the instances described above are the "sad exemplars" of a Constitution strained to breaking point by a clashing of powers.

10. The Achievement of Federation.

Even at the time when separatist tendencies were most marked in Australian affairs, thoughtful men foresaw that a time would come when cohesive forces would assert themselves. The Committee on Trade and Foreign Plantations, which reported to the Queen in 1849—Sir J. Stephen drafted the report—although recommending that the wishes of the Colonies respecting separate Governments should be carried out, nevertheless recommended that there should be a common Tariff. "So great indeed would be the evil, and such the obstruction of the inter-colonial trade, and so great the check

to the development of the resources of each of these Colonies," from the operation of separate Tariffs, "that it seems to us necessary that there should be one Tariff common to them all, so that goods might be carried from the one into the other with the same absolute freedom as between any two adjacent counties in England." The Committee recommended further that there should be established a House of Delegates elected by the legislatures of the different Colonies, with power to make laws of general application on ten subjects, namely: duties on imports and exports; postal affairs; roads, canals, and railways; beacons and lighthouses; shipping dues; weights and measures; the establishment of a general Supreme Court of original jurisdiction and appeal; the determining of the jurisdiction, forms, and manner of proceeding of such Court; the enactment of laws affecting all the Colonies on any subject not specified in the preceding list but on which the House of Delegates should be desired by the separate Legislatures to legislate: and the appropriation of revenue for the objects enumerated.

It will be seen that this was a scheme of federation, formulated half-a-century before the Colonies themselves agreed upon a basis of union. The most important omission from it is a provision for common defence, but it must be remembered that at the time when the Committee deliberated British troops were stationed in Australia, and the power of the Colonies to make adequate provision for their own defence was hardly contemplated. But the Act of Parliament passed in 1850 did not embody the Committee's scheme, though the title of Governor-General was conferred upon the Governor of New South Wales, and was borne by him until 1861.

The six Colonies of Australia, then, went on their own way. They had their separate Governors, Governments, and Parliaments. They legislated for their own internal requirements, without regard to the neighbours across their borders. They imposed Tariffs which operated against the goods of fellow Australians precisely as they operated against foreigners. A pair of boots imported to South Australia from Victoria paid just as much duty as a pair of boots imported from France or America. Not only were manufactured goods taxed. Victoria imposed a stock tax in the interests of graziers, so that even in a time of scarcity cattle brought over the border from New South Wales was taxed at so much per head. A Victorian statesmen, Sir James Patterson, coined the phrase "the barbarism of borderism," but the system was maintained.

Meanwhile, the ripening of political thought in the direction of federation was accelerated by extra-political forces. Railways and telegraphs abbreviated space and time, linked together previously isolated communities, made commercial intercourse facile, and emphasized the inconvenience of hindrances to its fluidity. It was not till 1883 that railway communication between Melbourne and Sydney was established; not till 1887 that Adelaide was connected by rail with Melbourne; not till 1889 that Sydney and Brisbane were joined. A line giving southern and eastern Australia access to Perth in the extreme west is only now in process of construction. The telegraph assisted materially in the unifying process. In 1872 a work of magnitude was achieved when the overland line from Adelaide to Port Darwin was completed. By 1877 there was telegraphic connexion between all the State capitals.

The ineffectiveness of the separate Colonies for dealing with questions affecting Australia as a whole likewise impelled thoughtful men to consider the necessity for union. Australians are of European, chiefly British, origin, and have kinship with the people of North America; but their continent is neighboured by thickly-populated Asiatic countries, whose customs and standards of living are alien from those prevailing here. Soon after the establishment of representative government, New South Wales, Victoria, and South Australia found it desirable to legislate to exclude Chinese immigration. More stringent laws were passed in the eighties. But still it was felt that Australia required to act on this question through a strong central authority. The employment of South Sea islanders (Kanakas) on the sugar plantations of Queensland introduced another alien element deemed socially undesirable, and if the traffic was to cease, Queensland must have a free extended market for her sugar, and the industry must be an Australian concern.

Again, the defensive organization of the country was weak and inefficient as long as each of six States had its own little force, and acted without co-operation with its neighbours. There were also questions vitally affecting the future well-being of the country upon which it was desirable that Australia should speak authoritatively. One such occurred when Bismarck inaugurated a German colonial policy. There were grounds for believing that Germany intended to appropriate New Guinea. That territory lay so near to the northern shores of Australia that the prospect caused some excitement. The Queensland Premier, McIlwraith (1883), telegraphed to London urging the Imperial Government to annex New Guinea, and offering to bear the cost of administration if that were done. New South Wales, Victoria, and South Australia agreed to co-operate. While Lord Derby, the Colonial Secretary, delayed, McIlwraith acted. News of a German move came to hand, whereupon the Queensland Government sent up a force to take possession of the southern part of New Guinea and to hoist the British flag at Port Moresby (April, 1883). It was an audacious stroke, but it succeeded. The Imperial Government could not, in the face of strongly expressed Australian opinion, do more than disavow responsibility. In the following year Germany did annex northern New Guinea, which was named Kaiser Wilhelm's Land, and also marked out for herself a sphere of possession and influence in the Pacific. The raising of this question was of great value in enlarging the Australian political horizon, in making people realize that the well-being—the security even—of their own separate Colonies, in whose domestic affairs they had been so engrossed, was affected by considerations of which they had been too negligent. Questions relating to the French in the Pacific began to engage serious attention. But how could six Colonies acting separately speak decisively on such matters of world politics as these?

A move in the direction of union was made in 1885, when a Federal Council was established. It had no legislative authority and no source of revenue. It could draw up statutes on a few specified subjects, but had no power to enforce them. It was still more ineffective because New South Wales did not participate in its deliberations. Still, the Council did afford a means of ventilating periodically questions affecting Australia as a whole, and its

proceedings were always watched with interest. Abortive attempts to frame an acceptable Federal Constitution were made at Conferences held in 1890 and 1891. The provisions of the draft instrument of union prepared at the latter Convention were discussed far and wide, and were of the utmost value in crystalizing opinion, not only on points on which federation was desirable, but also on the hindrances to the achievement of it. There was an interval of a few years, during which the question matured in the public mind. Societies discussed it; leagues were formed to advocate the cause; public men pronounced on important phases of it: there was a considerable pamphlet literature. An extra-official Conference at Corowa gathered up the threads and formulated a practical plan of procedure. At length, in 1895–6, the movement brought federation within the range of practical politics. The Parliaments of New South Wales, Victoria, South Australia, and Tasmania passed Acts enabling a Convention to be elected by the people to prepare a Federal Constitution. The Western Australian Parliament did not trust the people of the State, but elected delegates itself. Queensland, for the time being, did not participate. The Convention held three sessions in 1897–8, and finally brought forth a Bill. The measure was almost at once accepted by the people of three States by referendum; but certain of its provisions created dissatisfaction in New South Wales, and had to be amended at a Conference of Premiers before it was made acceptable to that State. One of the amendments made insured the establishment of the federal capital in New South Wales, but with the condition that it should not be within 100 miles of Sydney. In its amended form the Bill was accepted by the people of five States, and the sixth (Queensland), which had not been represented at the Convention, determined to enter the Union. The Imperial Parliament made an amendment of some consequence, ensuring the right of Australian litigants to appeal from the High Court to the Privy Council, except in cases affecting the constitutional powers of the Commonwealth or of States. But at length, in July, 1900, Queen Victoria gave her assent to the Act establishing a Government and Parliament for the Commonwealth of Australia, and in 1901 the present King—then Duke of York—formally opened the first Parliament, and set the machinery of the new Government in motion.

It is not possible within the space prescribed to relate the history of Australia under Federation. The thirteen years have been crowded with incident, and have witnessed remarkable changes in political complexion. They have witnessed the achievement of power by a new party with a stock of ideas partly evolved from British Radicalism, and partly from European Socialism, but adapted to Australian conditions and requirements. In 1895, so keen a political observer as Jenks could write a *History of the Australasian Colonies,* without mentioning the existence of a Labour Party as a factor of serious consequence. In 1904, only nine years later, there was a Labour Government—the Watson Administration—in charge of the affairs of the Commonwealth. That political developments occurred on other lines than those foreseen by the framers of the Constitution should not have been surprising to any student of comparative and historical politics; but few could have expected so rapid a demand for radical alterations in the Constitution itself as the leaders of the Labour Party are convinced is necessary

to the carrying out of their policy. These changes have been twice submitted to the electors, but have not been approved, though it is a fact of significance that the vote in favour of them at the last referendum (1913) showed a distinct advance upon the affirmative vote at the previous submission in 1911.

The creation of the Labour Party as a political power of first-class importance has, of course, caused prominence to be given to industrial legislation. Apart from this, the main matters of policy laid down, on the principles of which there is scarcely a difference between parties, relate to the exclusion of undesirable immigrants, including all coloured peoples; the protection of Australian industries, by a tariff, against foreign competition; the development of the defensive power of the country by a system of compulsory military training, and the establishment of an up-to-date fleet, to act in co-operation with British fleets. The Northern Territory, that is, the immense area extending from the northern border of South Australia to the Arafura Sea, was from 1863 administered by South Australia, and entailed heavy financial responsibilities. In 1907 the Federal Government assumed responsibility for it, and is now vigorously prosecuting a policy of development. The Commonwealth in 1906 took over the government of British New Guinea, which was re-named Papua, and here also there has been an application of capital and science. The choice of a site for a federal capital was the subject of prolonged investigations, negotiations, and parliamentary contention; but at length, in 1908, a situation in the district of Yass-Canberra was selected. Designs have been approved, and the work of construction is in progress. It was determined in 1913 that the name of the capital should be Canberra. The city when built will be connected by rail with a port at Jervis Bay.

11. Bibliography.

The limitations of this brief history of Australia have permitted the many phases to be indicated only in a summary manner; and it is desirable to append a short list of books whence fuller information may be obtained. The best compendious history is that of A. W. Jose, *History of Australasia*. The latest edition (Sydney, 1913) is an admirable book. It is well illustrated. Jenks' *History of the Australasian Colonies* (Cambridge, 1895, and later editions) is especially valuable for its chapters (VII. and XI.) on constitutional matters. Rusden's *History of Australia* (2nd edition, 1897) is in three volumes. G. B. Barton's *History of New South Wales* (1889) is limited in scope, but very good. The eight volumes of the *Historical Records of New South Wales*, edited by F. M. Bladen (Sydney, 1893–8), contain valuable documentary material up to the year 1813. Most of the early literature concerning New South Wales is rare, and some of it is very costly. One useful early book, Collins' *History of New South Wales* (1798), has been reprinted (1810). Collingridge, *First Discovery of Australia* (1906) and Favenc, *History of Australian Exploration* (1888) are useful books. Becke and Jeffery, *Naval Pioneers of Australia* (1899) is good. Scott's *Terre Napoléon* (1910) deals with the French explorations. Marion Phillips, *A Colonial Autocracy* (1909) is an excellent monograph on the *régime* of Governor Macquarie. The best history of a State since the spread of settlement from Sydney is the *History*

of the Colony of Victoria of Henry Gyles Turner (1904). The same author has written a volume on *The First Decade of the Australian Commonwealth* (1911), and (1913) a good little book on the Eureka Stockade incident. Hodder's *History of South Australia* (1893) is also a work of repute. The historical introduction to Quick and Garran's *Annotated Constitution of the Australian Commonwealth* (1901) relates the story of the federal movement authoritatively. On the Federal Constitution the principal work is that of Harrison Moore, *The Constitution of the Commonwealth of Australia* (latest edition, 1910). B. R. Wise's *Commonwealth of Australia* (1909) is written with a full knowledge of the currents of thought that shaped public opinion. The same author's *Making of the Australian Commonwealth* (1913) is an admirable "record by an eye-witness" of the critical period from 1889 to 1900. Of biographical works, three of particular value may be mentioned: Henderson's *Sir George Grey* (1902), Lyne's *Life of Sir Henry Parkes* (1897), and Morris' *Memoir of G. Higinbotham*. Parkes' *Fifty Years of the making of Australian History* (1892) is autobiographical and of considerable value. There is a useful chronological table of the chief events since the establishment of settlement in Australia in the Commonwealth *Official Year-Book*, 1913.

CHAPTER II.

THE ABORIGINALS OF AUSTRALIA.

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SYNOPSIS.

1. Introduction.

In the short space available it is impossible to do more than touch upon certain of the more important features in regard to the aboriginals. It is probable that, with the exception of one or two isolated groups, they represent the most backward race extant and, in many respects, reveal to us the conditions under which the early ancestors of the present human races existed. It must, however, always be remembered, from the point of view of savage life, that conditions in Australia, during the time that it has been inhabited by human beings, have differed much from those in Europe, Asia, Africa, and America, in that first, Australia has never been stocked with wild animals dangerous to human beings or with any apparently suitable for domestication. Even supposing there had been animals suitable for domestication, it is quite possible that the aboriginal would have done nothing with them. There are plenty of grass seeds that he uses daily to grind up and make into crude cakes, but it never strikes him that it would be advantageous to sow the seed, and so insure a certain amount of safe food supply. In many tribes at least this is to be associated with the fact that he knows nothing of the relation between the seed and the adult plant and thinks that the latter grows because he makes it do so by means of magic. Secondly, and perhaps more important, the Australian aboriginal, since the present race has inhabited the continent, has never had to contend with any higher race. He has developed along his own lines without the impetus given by competition with other peoples. In Europe, early man had to contend with bisons, rhinoceros, tigers, lions, bears, and hyaenas, a condition of affairs which must have sharpened his wits; in Australia he has had nothing more fearsome to meet than huge diprotodons and giant kangaroos, who were quite as anxious to get away from him as he was to capture and eat them. All that he has had to contend with have been men of his own, or a lower level, and, at times and in certain parts, climatic conditions that trained him to habits of keen observation.

In writing this account I have relied principally on the following works for information with regard to the tribes inhabiting the different parts of the continent with which they respectively deal —

(1) A. W. Howitt "Native Tribes of South-east Australia."
(2) W. E. Roth "Ethnological Studies amongst the North-west Queensland Aborigines" also Bulletins published by the Queensland Government.
(3) B. Spencer and F. J. Gillen. (1) "Native Tribes of Central Australia." (2) "Northern Tribes of Centralia"
(4) John Mathew. "Two Representative Tribes of Queensland"
(5) Mrs. D. M. Bates. "Social Organization of some Western Australian Tribes." Report A.A.A.S. Melbourne. Vol XIV., 1913.

There has been much speculation in regard to the origin of the present Australian race.* There can be no doubt but that in past times the whole of the continent, including Tasmania, was occupied by one race. This original, and probably Negritto population, at an early period was widely spread over Malayasia and Australia, including Tasmania, which at that time was not shut off by Bass Strait. The Tasmanians had no boats capable of crossing the latter and must have gone over on land. Subsequently, there came a time when the land sank, leaving the higher parts above water in the form of King Island on the west, and the Kent, Furneaux, and Flinders Islands on the east. A remnant of the old Negritto population was thus left stranded in Tasmania, where *Homo tasmanianus* survived until he came in contact with Europeans and was exterminated. There seems to be no doubt about this; what happened next is not so clear. *Homo tasmanianus* had frizzly hair, characteristic of negroid races. His weapons and implements were of the most primitive kind; long, pointed, unbarbed spears, no spear thrower, no boomerang, simple throwing sticks and only the crudest form of chipped stone axes, knives and scrapers that were never hafted.† Unfortunately, of his organization, customs, and beliefs we know but little in detail. It is often, indeed usually, assumed that (1) at a later period an immigration of a higher race took place, and that (2) this race blended with the older inhabitants of the continent to produce the present Australian race. In regard to the first of these two assumptions every one is agreed, but in regard to the second there is room for grave doubt.

Mr. J. Mathew suggests that "a superior race, akin perhaps to the Dravidian of India, the Veddahs of Ceylon, and the Toalas of Celebes, though not necessarily derived from one of these lands, migrated into Australia from the north-east. . . . . . . They pressed forward gradually, absorbing or exterminating the lowlier earlier inhabitants. . . . . . The vestiges of the Tasmanian are more pronounced in Victoria, which is shown by the fact that the Victorian dialects contain a number of pure Tasmanian words. The Australians of historic times are, therefore, a hybrid race, constituted mainly of the Tasmanian and Asiatic elements." Mr. Mathew suggests that "the two races are represented by the two primary classes or phratries of Australian society, which were generally designated by names indicating a contrast of colour such as eaglehawk and crow. The crow, black cockatoo, etc., would represent the Tasmanian element; the eaglehawk, white cockatoo, etc., the so-called Dravidian." I do not, however, think it can be said that the moiety names, except in a few cases, and these representing only a small part of the continent, lend any serious support to the theory of the mixture of two races differing in colour.

Mr. Mathew also postulates a comparatively recent slight infusion of Malay blood in the northern half of Australia. There is, however, practically no evidence of Malay infusion. One of the most striking features of the Malay is his long, lank hair, and yet it is just in these north parts that the most frizzly hair is met with. Judging indeed by all accounts, the Malay had very little chance of intercourse with the aboriginal, who killed

* For recent discussions on this subject reference may be made to Howitt, "Native Tribes of South-East Australia" and J. Mathew, "Two Representative Tribes of Queensland."

† Such information as we have is collected in "The Aborigines of Tasmania," H. Ling Roth, 2nd Edit. 1899.

the intruder when he could. Mr. Sydney H. Ray,* the most competent authority, says :—" There is no evidence of an African, Andaman, Papuan, or Malay connexion with the Australian languages. There are reasons for regarding the Australian as in a similar morphological stage to the Dravidian, but there is no genealogical relationship proved."

Of one thing I think we may feel quite sure, and that is that if we have two savage races, whom we will call A and B, and if one is on a higher level of culture than the other, has better weapons and is generally more capable, there is not the slightest chance of any men of the lower level, say B, mating with women of the higher level A. Nor is there much likelihood of a man of the higher race mating with a woman of the lower. As a matter of fact it is most probable that the lower race would be exterminated, just as the Moriori was in New Zealand by the incoming Maori. Mr. Mathew's theory, on the other hand, requires the two races—a lower and a higher one—to combine on equal terms. In the case of an invading race occupying the country of another that is living in more or less settled communities, some such union might take place, but we must remember that, in the case of Australia, we are dealing with wild, savage nomads, and, judging by what we know of the feelings of the present day natives in regard to strangers, it is almost inconceivable that any such combination would take place. The same objection, to a large extent, applies to the theory put forward first by Messrs. Flower and Lydekker and adopted by Dr. Howitt, of the mixture of the original Negritto with a dark-coloured Caucasian. It is, at least, very doubtful if the present Australian race shows any trace of intermixture with the primitive Negritto that formerly inhabited the continent, and it is at all events very suggestive that we never meet amongst recent Australians with any indication of real frizzly hair, one of the chief characteristics of the Negritto. If there had been any such blending we might expect to find some such trace of it in the south of the continent where there is none. Some authors regard the Australian as a pure race, but it is much more probable that it is a blend, but between what races it is thus a blend is a matter of conjecture only. Careful anthropometric investigations carried on in Professor Berry's laboratory in the Melbourne University seem to have established the fact that, of the three races, Tasmanian, Papuan, and Australian, the first is the most pure, the second the least, and the third midway between them. The general position occupied by the Australian and Tasmanian aboriginals in regard to various prehistoric races is indicated on the accompanying chart (Fig. 1), drawn up by Mr. Holmes, as the result of a series of skull measurements made on a large number of

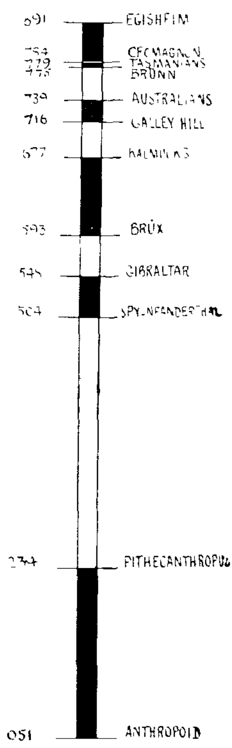

FIG 1

Chart illustrating the position held by Australian and Tasmanian Aboriginals in relation to extinct races. Drawn by W. M Holmes, M.A. B Sc

* Reports Camb. Expd. to Torres Straits, 1907, p. 258.

aboriginals.* A certain value is allowed to selected important characters, and the whole results are then worked out mathematically, giving the relative positions of each of the specimens and groups indicated. The diagram is very interesting and yet, despite the results that it shows, there is no doubt at all that the present Australian aboriginal is considerably in advance of the Tasmanian. His weapons are notably superior to those of the latter, and it is quite certain that, if the two races came into contact, the Tasmanian would be exterminated, although as is shown in the chart, the Tasmanian, in skull measurements, is placed above the Australian. Very evidently skull measurements are liable, if taken alone, to give rise to misleading conclusions.

The accompanying illustrations (Figs. 2–10) will serve to give a general idea of the physical features of the Australian native at different periods of his life. At birth he is copper coloured, but within a few days he assumes the usual dark chocolate tint characteristic of the adult.

In the matter of personal appearance, while conforming generally to what is known as the Australian type, there is considerable variation. The man varies from, approximately, a maximum of 6 ft. 3 in. to a minimum of 5 ft. 2 in. There are, however, very few aboriginals indeed who reach the maximum height indicated. As a general rule, few of them are taller than 5 ft. 8 in. The women vary between 5 ft. 9 in. and 4 ft. 9 in. Their average height is not more than 5 ft. 2 in. The brow ridges are strongly marked, especially in men, and the forehead slopes back. The nose is broad, with the root deep set. In colour, the native is dark chocolate brown, not black. The hair in the men varies to a very great extent. It may be almost straight, decidedly wavy—its usual feature—or almost, but never really, frizzly. The figures will show this well. The beard also may be well developed or almost absent. In some parts, the elder men pull the hair out on the upper and lower lips, an extreme example of which is met with on Melville Island where, during initiation ceremonies, some of them pull out the whole of their beards. The women very seldom have hair of any length, which is due to the fact that it is periodically cut; at all events, it is a common feature of drawings and photographs of women from all parts that the hair is never more than a few inches long and, in all the central and northern tribes, it is the duty of a woman to cut her hair and make it into string.

In skull measurements the native is dolichocephalic or long headed. His hands are decidedly small, the average span being little more than 6 inches. The hole cut for the hand in many of his shields is too small for an ordinary white man to use. Every native is marked by scars, the number and arrangement of which vary much (Fig. 5). It has been stated that these scars indicate either the tribe or the class of the individual. This may be so in some cases, but only very rarely. In all the central and northern tribes, amongst whom they are especially well developed, they have no relation whatever to any tribal, class, or totemic group, with the solitary exception of the Melville Islanders, who may always be recognised by their remarkable series of cicatrices, forming a "herring-bone" pattern. The cuts are made with a sharp stone, ashes, or birds' down being rubbed into

* I am indebted to Professor Berry for permission to use this chart.

the wound. which gives rise to a thick. rib-like mass of keloid tissue. They are present on women as well as men and are regarded as ornamental. In some cases. instead of lines there are dots made by searing the skin with the red hot end of a firestick. Various authors have referred to the scars on the women as evidence of harsh treatment. This is not so; they are self-inflicted.

In regard to their manner of life it must be remembered that they are pure nomads. the members of a tribe hunting over the land that has belonged to their ancestors and not encroaching on that of other tribes. There are favorite hunting and camping grounds and here they will stay as long as food and water supplies are abundant. moving on to other places when these become scarce. During the day they are out in the scrub, the men hunting larger game. the women and children in search of smaller animals, grass seed and yams. Attention has often been drawn to their great power of tracking, a faculty which they must cultivate if they are to live. Their evenings are spent in the performance of the ordinary dances called corroborees. in which, as a general rule. only men perform. while the rest of the camp makes the audience (Figs. 11 and 12). Each corroboree has its own decorations and songs and may occupy the evenings of two or three weeks. Apart from this ordinary camp life, there is. however. so far as the men are concerned. quite another side which may be spoken of as the ceremonial. It is difficult to say exactly how much time is occupied by this. but in many tribes at least half the life of a man is spent in attendance upon. or taking part in, ceremonies of a sacred nature that only initiated men may witness. and the older a man becomes the more time he spends in this way.

Finally it must be remembered that owing to the vast area over which the tribes are scattered and the very different conditions under which they live, some exposed to the often fierce heat and, it may be, droughts of the interior, others living amongst the shady forests of the south-eastern ranges, and others again camped by the side of the rivers and waterpools in the far north. with a constant and plentiful food supply, there are. of necessity, great variations in customs. organization and beliefs. It may be said that, so far as we are now acquainted with them, the different tribes may be regarded as descended from ancestors who all observed certain customs and were regulated by a common social organization. In course of time. as they wandered over the continent and became divided into groups, locally isolated from one another, they developed along different lines; and yet. amongst much that is divergent. it is. on the whole. surprising how much there is that is similar in their customs. beliefs, and organization.

2. Organization.

The first serious attempt to study Australian tribal organization in detail was made by Messrs. Howitt and Fison. who published their results from 1800 onward; *Kamilroi and Kurnai* may be regarded as having laid the foundation of our knowledge of Australian Anthropology. In this work they demonstrated the existence of (1) two primary exogamous moieties and (2) totemic groups. In the case of the Kamilroi tribe. the organization of a typical Australian tribe was set forth for the first time and it was shown

that the so-called "terms of relationship" were fundamentally group and not individual terms. At a later period Dr. Roth dealt in detail with the organization of Queensland tribes, Dr. Howitt published his final results in regard to the tribes of south-eastern Australia, the central and northern tribes were dealt with by the late Mr. Gillen and myself. Rev. John Mathew published his results of investigations into two Queensland tribes, and Mrs. D. M. Bates is now publishing the results of her work on Western Australian tribes.

As might be expected, there is great variation in regard to the organization of tribes inhabiting different parts of the continent. Speaking generally, we may say that every tribe is divided into two moieties; this is the fundamental feature.* Each of these is divided into two classes, and each of these into sub-classes, so that, in what may be regarded as the most highly developed normal tribes, we have two moieties with four sub-classes in each, and further the names applied to corresponding male and female sub-classes differ. This organization governs kinship and as, with its associated terms of relationship, it refers to the whole tribe and to every member of the tribe, so each individual has a kinship or relationship term that he applies to every member of his own tribe, and not only this, but to members of other tribes if they happen to visit his camp or if he goes to theirs, as may often happen during the performance of important ceremonies. These terms of relationship are quite different from those amongst ourselves and they might better be called group terms. In some, but very few cases, there are terms that are applied to individuals, but these are rarely met with, and it is only by realizing the fact that the group, and not the individual, lies at the basis of the organization of Australian tribes that, not only their organization, but their habits, customs, and beliefs can be understood. They have no terms corresponding precisely in meaning to our words mother, father, sister, brother, mother-in-law, father-in-law. In the Pitta Pitta tribe, for example, described by Roth in Queensland, a woman calls her actual mother "umma," but she applies the same name to each member of the group of women, any one of whom her father might have married. A man calls his actual wife or wives "nopa," but he applies the same term to each member of the group of women, any one of whom he might lawfully have married, and so on right through the whole series of terms. Not only is this so, but the group relationship shows out strongly during the performance of all their ceremonies and even in camp life. There are, for example, men of a certain group who may lawfully marry women of another group. If the father of one of his eligible wives dies, though the man may never have seen the father or his daughter, it is still his duty to cut himself in the same way as if his actual wife's father had died. So again, if he catches a wallaby, if there be any man in camp whose daughter he might lawfully marry, even if the man has no daughter, he must still present him with food. The affairs of any individual are, at bottom, mainly concerned with the group of which he is a member, the family enters to a slight, but only a very slight, extent. During the very large and by far the most important part of his life when he is associated with his fellow tribesmen, and often tribeswomen also, in

* For suggestions with regard to this, cf. John Mathew, "Eaglehawk and Crow," also "Two Representative Queensland Tribes."

the performance of the multifarious ceremonies that occupy so much of his time and thoughts, it is the group that is all predominant, the family is unrecognised.

In order to give some idea of the main features in regard to the organization of the tribes, we will take certain examples which may be regarded as representative of them, though, of course, only salient points can be noted in such a sketch as this. Taking Australian tribes as a whole, we may divide them into five groups :—

(1) Those with two moieties and no class names. In all of these descent is counted in the maternal line.

(2) Those in which the moieties are divided into two or four classes or sub-classes and in which descent is counted in the maternal line.

(3) Those in which the moieties are each divided into two or four classes or sub-classes and in which descent is counted in the indirect paternal line.

(4) Those in which the moieties are each divided into two classes and in which descent is counted in the direct paternal line.

(5) Tribes that may probably be regarded as abnormal, inhabiting coastal areas in certain parts, such as Victoria and the Northern Territory, in which, if any class organization were ever present, it has been superseded by some form of local organization.

(1) *Tribes with two moieties, but no classes.*

These are only met with in the interior of the continent, and probably represent the most primitive form of organization, but it must be remembered that, though there are no class names, yet there are groups of individuals, standing in definite relationships to one another, who correspond to the groups of individuals to whom class and sub-class names are given in other tribes. In some cases, the moiety names are Kararu and Matteri, or variants of these; in others they are Mukwara and Kilpara. Of these tribes we may take the Dieri as an example. A Kararu man marries a Matteri woman and their children are Matteri; a Matteri man marries a Kararu woman and their children are Kararu.

(2) *Tribes in which the moieties are divided into two classes, and descent is counted in the maternal line.*

We may take two examples of these—(*a*) the Pitta Pitta, described by Roth, the organization of which is similar to that of many of the Central Queensland tribes. It may be represented thus :—

1	2	3	4
Utaru.	Pakuta.	Children.	Children
Kupuru	Kurkilla	Bunburi	Wungko
Wungko	Bunburi	Kurkilla	Kupuru

The two moieties are Utaru and Pakuta, each of which has two classes. The system is, that men of column 1 marry women of column 2, and their children are shown in column 3. Men of column 2 marry women of column 1, and their children are as shown in column 4. It will be seen that a woman's children belong to her moiety but to the class to which she does not: in other words, we have direct maternal descent of the moiety and indirect of the class.

The second example is the Kamilroi, described by Howitt and Fison, the organization of which is similar to that of many tribes in the interior of New South Wales and Queensland. It agrees fundamentally with the Pitta Pitta, but has distinct names for males and females, thus:—

1	2	3	4
Kupathin	Dilbi	Children.	Children.
Ipai (Ipatha)	Kubi (Kubitha)	Murri (Matha)	Kumbo (Butha)
Kumbo (Butha)	Murri (Matha)	Kubi (Kubitha)	Ipai (Ipatha)

Descent is counted in the indirect female line, so far as the class is concerned, but, in addition to the ordinary marriage, it is permissible for a man to marry a woman belonging to the same moiety as himself, but to another totemic group. So far as the class name is concerned, the children take the one they would have taken had their mother married the correct man. It may be noted that in all tribes, when an irregular marriage is permitted, the children always take the class appropriate to the normal marriage of the woman.

(3) *Tribes in which the moieties are divided into two or four classes, and in which descent is counted in the indirect paternal line.*

These tribes occupy a very large area in the centre and northern parts of the continent, and probably extend right across into Western Australia; at all events, we know they stretch beyond the far western end of the Macdonnell Ranges, and are met with again in the West. The Arunta, Karriara, and Warramunga may be taken as types. The Arunta organization in the southern part of the tribe is thus:—

1	2	3	4
Moiety 1	Moiety 2.	Children.	Children.
Panunga	Purula	Bulthara	Kumara
Bulthara	Kumara	Panunga	Bulthara

In the southern part of the tribe there are only four class names, but, as a matter of fact, each of these is divided into two groups. If we take for example the Panunga and Purula, two intermarrying groups, we find that we can arrange them as follows, using the letters α and β to indicate the two groups :—

Panunga α marries Purula α, children are Bulthara β.

Panunga β marries Purula β, children are Bulthara α.

A Panunga α man calls Purula α women *Unawa*, Panunga β men *Ipmunna*, and Purula β women *Unkulla*. The Unawa women are eligible as wives, the Unkulla are not, under normal conditions. In the northern part of the tribe distinct names are given to the groups which now form what are called eight sub-classes, but, as said before, these are always functionally present.

The names and marriage arrangements are as follows, the equivalent groups in the southern part of the tribe being placed in brackets :—

Moiety 1	Moiety 2	Children.	Children.
Panunga	Purula	Appungerta	Kumara
(Panunga α)	(Purula α)	(Bulthara β)	(Kumara α)
Uknaria	Ungalla	Bulthara	Ubitchana
(Panunga β)	(Purula β)	(Bulthara β)	(Kumara β)
Bulthara	Kumara	Uknaria	Purula
(Bulthara α)	(Kumara α)	(Panunga β)	(Purula α)
Appungerta	Umbitchana	Panunga	Ungalla
(Bulthara β)	(Kumara β)	(Panunga α)	(Purula β)

The organization of the Kaitish, Warramunga, and other tribes in the northern central area, as far as the Katharine River in the north, and eastwards towards the Gulf of Carpentaria, is fundamentally the same with, of course, different names for sub-classes and, in many, distinct names for the corresponding women's classes, giving thus sixteen class names in all, a feature* described also by Mrs. Bates in East Kimberley tribes in Western Australia. Thus, for example, in the Warramunga, the equivalent of the Uknaria, men are called Tjunguri, and the women of the same group Namigilli. In some tribes also the moiety names are retained. In the Warramunga, the equivalent of moiety 1 in the Arunta is called Uluuru, and that of moiety 2 Kingilli. In the Karriara tribe in Western Australia, as described by Mrs. Bates, the moiety names are lost, four classes are present, and the marriage arrangements are as follows :—

1	2	3	4
Moiety 1.	Moiety 2	Children.	Children.
Banaka	Boorong	Paljari	Kaimera
Paljari	Kaimera	Banaka	Boorong

It will be seen that, except for the class names, the arrangement is identical with what is met with in the southern Arunta, and a similar organization is evidently widely spread in Western Australia.

* Mrs D. M. Bates. "Social Organization of some Western Australian Tribes." Report A.A.A.S., Vol. XIV., 1913.

(4) *Tribes in which the moieties are divided into four classes, and in which descent is counted in the direct paternal line, so far as the class name is concerned.*

The Mara tribe inhabiting country between the Roper and Macarthur Rivers may be taken as a type. The arrangement is as follows :—

1	2	3	4
Miluri.	Umbaua.	Children.	Children.
Murungun α	Purdal α	Murungun β	Purdal β
Murungun β	Kuial β	Murungun α	Kuial α
Mumbali α	Kuial α	Mumbali β	Kuial β
Mumbali β	Purdal β	Mumbali α	Purdal α

There are four classes, but each of these is again divided into two, distinguished by the letters α and β. The arrangement has the appearance of being very definitely thought out, and there is further a very definite scheme, by means of which the divisions (Murungun α, β, etc.) are made to fit in with the corresponding sub-classes in other tribes with whom the Mara constantly come into contact.

(5) *Abnormal tribes in which class organization has apparently been superseded by some form of local organization.*

As an example of these, we may take the Kurnai tribe which, many years ago, occupied the mountains in eastern Victoria. It was divided into five groups named after the localities in which they lived. There was no class organization and a man could not marry a woman of his own local group. There were intermarrying local groups, marriage being by elopement.

As a second example, we may mention the Kakadu and allied tribes living at the other extremity of the continent on the Coburg Peninsula and Alligator Rivers. They have apparently no class organization and the totem does not regulate marriage. The tribe is divided into local groups and a man of one local group takes a wife from another particular group. There are explicit traditions which purport to explain the origin of this local system.

3. Totemic Systems and Totemism.

In dealing with Australian tribes the word " totem " has been applied in at least three different senses.

(1) The *Group totem*, that is the material object giving its name to a group of individuals who commonly believe themselves to be descended from it. The name of the totem usually passes by inheritance from generation to generation, sometimes in the maternal, sometimes in the paternal line.

(2) The *Sex totem*, discovered by Dr. Howitt in the Kurnai and Wotjoballuk tribes in Victoria, where it exists side by side with the group totem. The women have one animal, such as the owlet night-jar, associated with them and the man another, such as the bat. This is of rare occurrence.

(3) The *Individual totem*, usually acquired by dreaming of some animal. This also is of rare occurrence and was first described by Dr. Howitt, but has been recently described by Mrs. Bates as occurring also in some Western Australian tribes.

So far as Australia is concerned, it is advisable to restrict the term totem to the first of these and to define it as a material object that (1) gives its name to a group of individuals and (2) the name of which is usually hereditary either in the maternal or paternal line and the term totemism to a system based on the recognition of these two factors. It must be remembered that there are very considerable variations in regard to totemic customs and beliefs in different tribes. We will deal with totemism under three aspects.

(1) The Social Aspect.

By this is meant the division of the tribe into totem groups, their influence, if any, on marriage and the mode in which each individual becomes associated with any one of them.

We have already seen that most tribes are divided into moieties and these into classes. As a general rule, the totemic groups are distributed between the two moieties in such a way that each group is confined to one or other of them. We will take a series of tribes from different parts of the continent as typical of the more important variations in regard to the social aspect.

(1) The **Dieri.**—This is representative of tribes in which the moieties are not divided into classes. These moieties are called Kararu and Matteri and the totem groups are divided between them. Kararu has rain, carpet snake, crow, frog, etc.; Matteri has a cormorant, emu, eagle, hawk, native cat, etc. A Kararu man must marry a Matteri woman and is not restricted in his choice to any one totem group. The children follow the mother's totem.

(2) The **Kamilroi.**—This is representative of a large number of tribes, such as the Whakelbura, occupying a vast area of country sweeping round inland of the coastal ranges, from the Gulf of Carpentaria in the north to the River Murray in the south. The totems are divided between the moieties. There are four classes and of these Ipai-Kumbo and Murri-Kubbo have totems in common. The children take the mother's totem.

(3) The **Arunta.**—This is representative of an important group, including the Arunta, Ilpirra, Unmatjera, and Kaitish tribes. There are four classes or eight sub-classes and the totem groups are not restricted to the moieties. Each group is, however, always more largely represented in one moiety than the other. Marriage between individuals of the same totemic name is not forbidden, but rarely takes place. The country occupied by the Arunta is dotted over with special spots inhabited by the spirits of old totemic ancestors, who enter women and undergo reincarnation. The traditions are very precise in regard to these totemic centres, so that the natives knowing, or thinking they do, where any particular spirit child entered a woman, are able to assign its totem to it. In the Kaitish, the most northern of these tribes, the totemic groups are more nearly divided between the moieties than in the Arunta. A man very rarely marries a woman of his own totem

and there is a strong tendency for the descent of the totem to be in the male line, as is always the case in the class names. Each individual is normally associated with one totem group.

(4) The **Warramunga.**—This is representative of the Warramunga, Tjingilli, and other tribes occupying a large area in the centre and extending across to the Queensland border The totem groups are strictly divided between the moieties. A man may marry a woman of any totem in the moiety to which he does not belong, provided she belongs to the right class. Strict paternal descent of the totem is nearly, but not quite, the rule, but every child belongs to a totem group in its father's moiety. For example, a black snake man's children are almost always black snake, though rarely one may belong to another totem group such as rain. As the moieties are exogamous, it follows that the totems are the same.

(5) The **Binbinga.**—This is representative of a group of tribes that occupy the country drained by the Macarthur River flowing into the Gulf of Carpentaria. The organization is closely similar to that of the Warramunga, but in these tribes not only are the totem groups divided between the moieties, but the descent of the totem name is strictly in the father's line.

(6) There remain certain tribes in which the descent is anomalous, such, for example, as the Kurnai, in the southern coastal district of Victoria, and the Kakadu nation in the far north, occupying the Coburg Peninsula and the the country drained by the Alligator Rivers. These tribes are evidently much modified. They have no class system and marriage is regulated by the existence of local intermarrying groups. In the Kakadu each spirit individual has a double nature, one part enters the woman, one part remains outside. It chooses its own totem and the spirit part that remains outside tells the father the totem name of the child.

(2) The Ceremonial Aspect.

This side of totemism has probably been very strongly developed throughout the whole of Australia, though it has only been much studied during recent years, when, unfortunately, in the whole of Victoria and New South Wales and in most parts of Queensland, the tribes have become decadent It is interesting to note that one of the earliest accounts that we have of the natives—that given by Collins in 1804—evidently describes one of these performances. Speaking generally, it may be said that every totemic group has certain ceremonies associated with it and that these refer to old totemic ancestors In all tribes they form part of a secret ritual in which only initiated men take part. In most tribes a certain number are shown to the youths during the early stages of initiation, but at a later period he sees many more. In the Arunta, for example, the final stage is concerned with the Engwura and during the performance of this a long series is performed (Figs. 13 and 14). It may extend over a period of three months, during which totemic ceremonies are enacted daily. To start an Engwura, the leader of some totemic group, after consultation with those of others, sends out a messenger called Ilchinkinja, which means "the beckoning hand." He carries a Churinga and passes over the country delivering his message at different camps. Slowly the natives gather together at the chosen place, where a special ceremonial ground has been prepared. The Panunga-Bulthara camp together, and the Purula-Kumara, the division of the tribe

into two moieties being very marked during the Engwura. Large numbers of Churinga are brought in and stored on two platforms far from one another. These are associated with the old ancestors and their living representatives and at times the old men call some of the younger ones together, rub the sticks with red ochre and tell the former all about the ancestors. Each ceremony is concerned with an ancestor and is the property of some old man who either performs it himself or invites a younger man to do so. At the close of the Engwura the men have to pass through three fire ordeals. During the first the women throw burning bushes over them; during the second they have to lie down on bushes placed above red hot faggots and, during the third, they have to kneel for a few moments on a smouldering fire made by the women. Apart from this, the women take no part whatever in the ceremonies, after which are over the men are regarded as "ertwa mura oknira"—very good men. A characteristic feature of these ceremonies, the exact nature of which varies much in different parts of the continent, is that one or more men have their bodies decorated with a design which is especially associated with that ceremony and is usually drawn in coloured bird's down, always fixed on with human blood. Even more elaborate designs may sometimes be drawn on the ground (Figs. 29 and 30).

(3) The Magical Aspect.

In early days, Grey, who used the Western Australian word Kobong for totem, stated that "A certain mysterious connexion exists between a family and its kobong, so that a member of the family will never kill an animal of the species to which his *kobong* belongs, should he find it asleep; indeed, he always kills it reluctantly, and never without affording it a chance to escape. This arises from the family belief that some one individual of the species is their nearest friend, to kill whom would be a great crime and carefully to be avoided." This idea of a close association between an individual and his totem is widely spread, but the exact beliefs and customs in regard to them differ very much in different parts. The general idea may be summed up in a remark made to us by a kangaroo man when we had taken his photograph. We were asking him about the matter and he said, pointing to the photograph, "That is just the same as me, so is a kangaroo." In some tribes there is a feeling of mutual protection between an individual and his totem, but this is not often met with. They are of the same flesh and the belief in the descent from the totemic animal is widespread. In some tribes the individual will not kill his totem; but in most there is no objection to his doing so and handing it to others to eat. In some he will both kill and eat it. The exact nature of the relationship and the way in which the native is influenced by it varies much and, speaking generally, the magical aspect of totemism appears to be largely associated with climatic conditions, so far as they affect the supply of food and water. Three typical examples of ceremonies will serve to show the nature of the magical aspect. In the Urabunna tribe, which counts descent in the female line, the ceremony is called Pitjinta. In a snake group the decorated performer kneels down and extends his arms. The skin on each fore-arm is then pinched up and he pierces it with a pointed bone (Fig. 15). When snakes become plentiful, men who do not belong to the totem group go and bring some in to the old man and say, "Look, here are

snakes." He smears a little fat over his arms and the bone and then tells the men to eat the rest. The bones are wrapped in the hair of a snake man and put away. In the Arunta, the ceremonies are called Intichiuma and are very suggestive. In that of a grub group the men of the totem, no one else being present, start from camp in the morning in silence, fasting and devoid of arms and ornaments. Each man has a mark characteristic of the totem on his face. They go to a rocky gorge where there is a cave and in this a large stone that represents the adult insect and smaller ones that are its eggs. The former is reverently stroked by all while they chant refrains, the burden of which is an invitation to the insect to come and lay eggs. This over, they return to the camp, near to which a long bough hut has been built, supposed to represent the chrysalis case. Into this they all go and once or twice the leader comes out and shambles round in imitation of the adult insect emerging from its chrysalis. All men and women who do not belong to the group have to lie down with their faces on the ground while the women of the group stand up peering round in all directions and keeping watch over them. Some time later, when the grub is plentiful, every one goes out; they collect large numbers, return to camp and cook them. The head man sits by himself. First the men who do not belong to the group and then those who do bring their supplies to him. He eats a little, gives some to a few of the older men and then hands all the rest to those who do not belong to the group, telling them to eat it. The grub men are not absolutely forbidden to eat it but they only do so sparingly. The leader must at this time eat a little, so as to identify himself with it, or else he would not be able to perform the ceremony successfully. In the Kakadu tribe, far in the north, there is a ceremony called Muraian that is evidently of the same nature, though it is not so detailed, owing, doubtless, to the normal abundance of food in this part. The natives have a large number of sacred sticks and stones, each supposed to represent a totemic animal or plant (Fig. 16). They may only be seen by the elder men and, during the ceremony, are grasped in the hands of men who dance round and round a central figure, stretching out the symbolic objects and yelling "Brau, Brau," which means "Give, give." It sounds almost like a command to the totemic object.

In Western Australia Mrs. Bates has recorded that, in the East Pilbaru tribe, there are certain special spots, or local totem centres, called Thalu, where ceremonies for the increase of the totemic object are held, in which, unlike most tribes, women and children take some share. The same author describes how in the West Kimberley tribes the totems are "dreamed" by the totemites. When a young man has passed through some stages of his initiation, he begins to "dream" the increase of his totem. He dreams he is on his ngargarula booro (that is, the ground on which his father first saw him in a dream when he was a spirit baby). If he be an edible bean man, for example, he dreams he picks up a branch of the bean, chews it and spits it all about. When the time of beans comes round, a plentiful supply will result from the dream.

There is no doubt but that in many tribes, and the belief was probably at one time widely spread over Australia, the natives firmly believe that by means of magical ceremonies such as these they can control their food supplies.

4. Initiation.

In all Australian tribes special ceremonies of an important nature, which vary much in their details, attend both the initiation of youths to the status of men and that of girls to the status of women. In the case of the youth, initiation is almost universally associated with showing him the "bull-roarer" for the first time. It has different names in different parts—Churinga, Tundun, Kunapippi, etc.—but always consists of a thin slab of wood, or, more rarely, stone. It is pierced at one end by a hole, through which the string is passed, and by this means it is whirled round and round, making the noise that is usually supposed by women and children to be the voice of a great spirit that takes the youth away and initiates him. It is very difficult to understand the wide divergence in regard to the actual ceremonies characteristic of different groups of tribes. We have, generally speaking, three main types—(1) the knocking out of an incisor tooth, as amongst the Kurnai in the south-east; (2) circumcision, followed in many, but by no means all, cases by sub-incision, amongst tribes occupying a vast area in the interior of New South Wales and Queensland, the whole of the central area and probably a large part of Western Australia; (3) special ceremonies amongst groups of tribes such as those on Melville and Bathurst Islands and the Kakadu nation on the Alligator Rivers, amongst whom no mutilation of the body other than perhaps the pulling out of hairs takes place. We will briefly describe examples of each of these types.

Of the first we will take the Kurnai as being of historic interest, because it was in connexion with it that the first adequate account of initiation was given by the late Dr. Howitt, who then also drew attention, for the first time, to the importance of the bull-roarer. To begin with, a man is sent out with a Tundun to summon distant groups. This may take months. When they come in, ordinary corroborees are held which serve to fill in the time until all have arrived. A ceremonial ground, called Bunan, is prepared by clearing an open space 30 to 50 yards long, and piling earth round it to form a low mound. A path leads away for about 400 yards into the scrub, where a bush house is built. The serious part of the ceremonies begins by a recently initiated youth walking by a log placed near the Bunan, and saying "A snake, a snake." Other men come up, pretend to be frightened, and then they all run away in single file. At first the women and children gather together in the middle of the Bunan, the men on the outside. The latter then jump over the mound and run round the women shouting out the names of the various contingents that have come in. The women come out and the men go in. The novices are amongst the women and, like them, sit with their backs to the men. On the Bunan the tooth song is sung, after which most of the men go to the bush house where the medicine men show their "joias," or magic stones, to the possession of which they owe their powers. Here, also, there are figures of animals, such as the spiny ant-eater, crow, snakes and especially one of Daramulun, who is regarded as the great father of the tribe. This over, they return to the Bunan, the youths are painted and fillets of grass bound round their foreheads by their mothers' brothers, who take charge of them and instruct them in tribal legends, laws and the power of medicine men, etc. A hot fire is made on the Bunan and the novices sit round on the mound each with a woman's digging stick between his feet, containing the waist

belt, forehead band and nose bone that he will wear when initiated. Behind each boy, covered with boughs, crouches his mother or her sister. Then the bull-roarer sounds, the women run away and the youths are taken to the bush house and covered with boughs. Once more they return to the Bunan and are told of Daramulun. Finally, a man, representing the latter, takes hold of each boy, applies his lower incisor to the left upper of the boy and presses it up. Then the loosened tooth is knocked out with a club and chisel. After this, the boys are shown a special image of Daramulun, instructed in their duties as men and told that the women must know nothing of what they have seen. Finally, they are taken and shown to the women, from whose charge they have now been removed, and then run off into the bush.

In the second type, including those of Central Australia and the Queensland tribes described by Roth, there are a succession of initiation ceremonies taking place at various ages. The Arunta may be taken as a type. We have—(1) the painting of the young boys and throwing them in the air, (2) the ceremony of circumcision, (3) that of sub-incision, and (4) the Engwura. In connexion with the second, the youths are shown the bull-roarer for the first time, the noise made by which the women and children believe to be the voice of Twanyirika, a spirit that takes the boys away, provides them with a new set of insides and makes them into men. In connexion with both (2) and (3), they are shown sacred totemic ceremonies and instructed in the laws, totemic history of the tribe, food restrictions and their duties as men; they are told that they must implicitly obey the old men, must not eat the forbidden foods, but supply other men with them, and on no account must they talk to lubras about what they have seen. Everything is made as impressive as possible and the fact that the main ceremonies take place during the night, or just at daybreak, adds to the feeling of mystery. They have special designs painted on them, may not speak to any one save the old men in charge of them, are given very little food to eat, and pass through sundry very unpleasant experiences. For example, at various stages during the performance of kangaroo ceremonies, from four to ten men lie down on the novice, who is expected to bear everything with stoicism. Finally, the men take about a dozen poles, each 8 feet high. Dry boughs are piled up to make a fire and, amidst the yells of the men, the women rush to their camp while bull-roarers sound all round. The novice is laid on his back and the poles placed above him and lifted up and down on him while the men sing. This over, he is carried, feet foremost, to where a man, kneeling in front of the operator, holds a shield on which he is placed and then, to the weird accompaniment of the bull-roarers, the Lartna song is thundered out and, in a moment or two, the operation is over. The initiated youth, completely dazed, after being embraced in turn by each of the older men who has taken an official part in the ceremony, is handed a bundle of churinga, and told, "Here is Twanyirika, of whom you have heard so much, take them, they are churinga and will help to heal you quickly, guard them well, do not lose them, do not let your mother and sisters see you, obey your elder brother, who goes with you, do not eat forbidden food."

The final ceremony of Engwura, to which we have referred under the heading of totemism, is not passed through until a man is perhaps 25 or 30 years

old. It is most impressive and, after a man has passed through it, he is spoken of as "ertwa mura oknira," which means "very good man." As a matter of fact, every man must pass through all the initiation ceremonies, so that, amongst the elder men, there is no one who is not "ertwa mura oknira," but, on the other hand, there are grades of "goodness." Some men take less interest than others in the sacred ceremonies, they are given to chattering, like women and children and are "irkun oknira," that is, light and frivolous. Others take matters seriously and will, as they grow older, become leaders or oknirabata—great teachers.

Special status names are applied as follows to the boy, youth and man at the times stated :—(1) Ambaquerka at the time of growing up, (2) Ulpmerka after this and until circumcision, (3) Wurtja during the ceremony, (4) Arakurta after the ceremony and until that of sub-incision, (5) Ertwakurka after this and until the Engwura, (6) Uliara after the latter. As in the Kurnai, so in all tribes, the women take an active part in the opening ceremonies but are rigidly excluded from the essential parts when a bull-roarer is used. There is usually some special ceremony symbolic of the fact that the boy is being withdrawn from the ranks of the women. It is not necessary here to refer to the initiation ceremonies of the women, but such exist in all central tribes and in those described by Roth, and probably, at one time, existed universally.

The third type includes various coastal tribes that are evidently much modified. A characteristic group of these inhabits the Coburg Peninsula, the Alligator River district and the coast as far as Darwin. A still more modified group inhabits Melville and Bathurst Islands. The former have a remarkable series of ceremonies associated with initiation, all of them totemic in character. There is no tooth knocking out nor any mutilation of the body. In the Kakadu, a special ground called "ober" is made, and on this totemic ceremonies are shown to the novices, who are given the usual instructions. Like the Arunta, there are various grades, the last of which is not passed through until a man is old, when he is allowed to take part in the Muraian ceremony, during which various objects symbolic of the totems are used. In the Kakadu there are apparently no bull-roarers shown; but in the Larakia, at Darwin, they are shown to the young men at one stage, when three or four old men suddenly emerge from the bush and whirl them in front of the novices. The latter stand in a row, and the old men, coming right up to them, point the bull-roarers at them, then pull them through their own armpits, and insert them in those of the novices. At other stages the novices are subjected to rough treatment, such even as being kicked and hit hard, and during these unpleasant performances they must not grumble or find fault. On Melville Island, the novices are shown a special yam ceremony, during which all the men, women and children are gathered together in a camp, where ceremonies are performed and the yams cooked and eaten in a special way. The novices are also taken to a water-hole, where those who are passing through for the first time have their heads placed in bark baskets and dipped under water, while those who have reached the second stage are caught hold of by the arms and legs and pulled violently backwards and forwards through the water. Amongst these tribes girls of corresponding status to the youths are specially decorated and take part in the ceremonies,

south-eastern part of the continent. In the Narrinyeri Tribe there was a Being called Nurrundere, who was supposed to have made everything and to have instituted their rites and ceremonies. The Wotjoballuk spoke of Bunjil as "our father" and the Kulin people believed that he was an old man with two wives, taught them the arts of life and divided the tribe into intermarrying groups. In the Kurnai, Bunjil was a great Being, all knowledge of whom was confined to the men. The Kamilroi looked on Baiame as the Being who created all things. Amongst the Yuin people Daramulun is supposed to have instituted the ceremonies and made the bull-roarer. He lived in the sky, watching the men. His name is only used by the initiated. In parts of Queensland they believe in Kohin who lives in the Milky Way, roams about at night as a warrior, killing all natives he meets, and who is also offended if they do not keep the customs. According to Mr. Mathew, the Kabi and Wakka tribes believed in Beings such as Biral, Jonjari and Dhakkan, who was identified with the rainbow and lived in deep water holes. He could shatter mountains, slaughter natives and was at times malignant. He substituted half-caste for pure-bred children, so he was called *warang*, that is, wicked.

Dr. Howitt sums up the legends and teachings, so far as the south-eastern tribes are concerned, as follows :—"I see, as the embodied idea, a venerable, kindly, headman of a tribe, full of knowledge and tribal wisdom and all powerful in magic, of which he is the source, with virtues, failings and passions, such as the aborigines regard them."

In the Central tribes there is everywhere a belief in the former existence of ancestors endowed with powers superior to those of living natives. In addition there are other Beings. The Arunta believe that long ago there were two, called Ungambikula, which means "made out of nothing." They lived in the sky and came down and made men and women and then they turned into lizards. The Arunta also believed in the existence of mischievous spirits, called Oruncha, who are always ready to injure natives, but they have no great spirit such as Baiame. They have a mythical Being called Twanyirika, the equivalent of whom is found in other tribes, who is supposed by the women and children to take the boys away at initiation and provide them with new "insides" and whose voice is heard when the bull-roarer sounds. The men, however, tell the youths that the sound is made by the roarers. There is a belief amongst the Kaitish tribe in a Being called Atnatu. He made himself, the stars are his wives and he has plenty of sons and daughters. Long ago he was angry with his children, so he dropped them down on earth and, with them, everything the natives now have. If he hears the bull-roarers sound he is pleased, but if not he is angry. The Binbinga on the Gulf of Carpentaria believe that there are two malignant spirits called Mundagadji, anxious to hurt them, and a friendly one, named Ulurkura, who lives in the woods and stops the Mundagadji.

Speaking generally it may be said that every tribe has a belief of some kind in Superior Beings ; that, with rare exceptions, the latter are not supposed to take any personal interest in the natives or to be pleased or displeased with what they do ; that no appeal for help is ever made to them, and that they have nothing whatever to do with the inculcation of moral precepts.

7. Magic and Medicine Men.

It is difficult to overstate the extraordinary part that, in one way or another, magic plays in a native's life. From the moment that he is born until he dies he lives in an atmosphere of magic. There are two sides to magic, the evil and the good and, of the two, the former bulks more largely in the native mind. Of good magic we have, on the one hand, ceremonies such as those in which, for example, a man of the Yam totem will take one of his yam churinga, "sing" it and then deposit it on ground where yams are usually found, with the idea that he can thereby make them grow. On the other, we have magic called into existence to counteract evil magic. In some tribes any man, or even women, may perform evil magic, in others the power is confined to the medicine men, as is also, in all tribes, the exercise of curative magic. First of all, we will deal with the medicine men. There are various ways in which they are made. Sometimes an old medicine man will initiate a young man, but, more often, they are supposed to be made by supernatural beings of some kind and in most, if not all, cases the medicine man has in his body something in the form of small crystals which are the seat of his "virtues" and can be projected into the body of the patient in whom, as the case may be, they may either cause trouble or counteract evil magic implanted by some other individual. The medicine men also communicate with the spirits and it is they only who can withdraw "poison bones and sticks." They often fly into the sky during the night, visiting hostile camps, inserting bones and sticks into enemies and sometimes, by means of invisible ropes, can climb up and down between earth and sky. Some even are strong enough to ward off evil magic from a whole tribe. At the time of the 1901 comet, a powerful Kaitish medicine man saved the whole tribe from destruction by night after night "singing" the comet's tail, and preventing the spears, of which it was made, from being hurled on to the Kaitish country.

The commonest form of evil magic is associated with pointing bones and sticks (Fig. 17). A typical form is described by Roth under the name of Munguni and may be taken as representative of this form of magic in Australia. The instrument used consists of a short pointed bone attached to a string that passes into and through a little hollow receptacle, made of bone or wood, and out at the opposite end which is closed. When in use the receptacle is held in one hand and the bone pointed towards the victim, who may be miles away. A double action takes place, some of the victim's blood is drawn into the receptacle, where it is sealed up and, at the same time, evil magic passes out to the victim. To kill the latter, the receptacle with its contents may be burned, but, just to keep the victim ill, it may be warmed every now and then. He will never recover until it has been thoroughly well rinsed out.

Another characteristic form is associated with an object called Tchintu It is only a small lump of resin with two teeth in it, and a long string attached but by being "sung" the heat of the sun can be drawn into it and then, if it be placed in the tracks of any one, the heat follows the victim up, enters his body and kills him.

Some of the most potent forms of magic are associated with hair cut from the bodies of the dead. They are used on avenging parties (Fig. 17),

and both endow the wearer with strength and accuracy of aim and, at the same time, render the victim powerless. Another favourite and wide-spread practice is that of "taking the kidney fat." This is usually done by hostile medicine men. In the Wotjoballuk tribe in Victoria, the latter sneaks on the sleeping victim. He carries a magic bone with a noose attached to it He may either project the bone into his victim, which action compels him to come out to the medicine man, who then throws him over his shoulder and carries him off, or, if the medicine man happens to be in camp with his victim, he passes the bone under the knees of the latter when he is asleep, round his neck and through the noose, rendering him helpless. In any case, the victim is oblivious of what takes place. The medicine man opens the right side of his victim just below the ribs and abstracts the fat, which may be eaten or rubbed on weapons. The wound is "sung" and the sides bitten together in such a way that no scar is left. The victim wanders back to camp but soon dies. No medicine man can cure one whose kidney fat has been extracted but he can determine, or even the patient himself may, who is the guilty one. Any medicine man can withdraw bones and objects of magic generally, and is always called in when a patient is ill. It must be remembered that no native believes in illness except as the result of evil magic, and magic from a distance is always potent. A pain is caused by some concrete thing that must be removed from the body and the method of procedure is very much the same in all tribes. The patient lies down, the medicine man comes up and gazes fixedly upon him, as often as not projecting some of his magic crystals into him to act as an antidote. Then, after prolonged sucking and massage, he will, perhaps, but only if he be a very gifted practitioner, withdraw the poison bone or stick whole; in most cases it is removed bit by bit (Fig. 18). Then, unseen by any one, his magic crystals return to his body.

It is difficult to estimate how far the medicine men believe in themselves They must know that, to a certain extent, they are frauds, though it is wonderful what they can persuade themselves to believe, and the truth probably is that, while each individual knows that he himself cannot do everything that he pretends to, yet he firmly believes that other men can.

8. Ceremonies Associated with Death and Burial.

Death is always supposed to be due to evil magic and may be brought about in various ways. Very often a bone, or stick, is sung and pointed in the direction of the victim whom its evil magic then enters. In some tribes a ceremony is performed with the object of catching the double of the man's spirit, without whose friendly guidance he meets with an accident (Fig. 19). Death is always a source of fear to natives, because in many cases it means not only that there is some evil spirit or magic influence at work, but also the spirit of the dead person is hovering about. It is customary to shift camp the moment a death occurs and in all tribes there are special ceremonies that must be carried out. They vary much, and are regarded as of great importance. I will describe the main points of those in the Arunta tribe, and afterwards note important features in those of other tribes. First of all, the deceased's hair is cut off and made into a special girdle, to be subsequently worn by a man who avenges the death

FIG. 2.—WARRAMUNGA BOY.

FIG. 3.—KARAWA BOY, GULF OF CARPENTARIA, SHOWING METHOD OF COILING HAIR INTO PLAITS.

FIG. 5.—TJINGILLI MAN—CENTRAL AUSTRALIA, SHOWING KELOID TISSUE.

FIG. 4.—BINBINGA MAN—GULF OF CARPENTARIA.

FIG. 6.—ARUNTA MAN—CENTRAL AUSTRALIA.

FIG. 7.—WORGAIA MAN—CENTRAL AUSTRALIA.

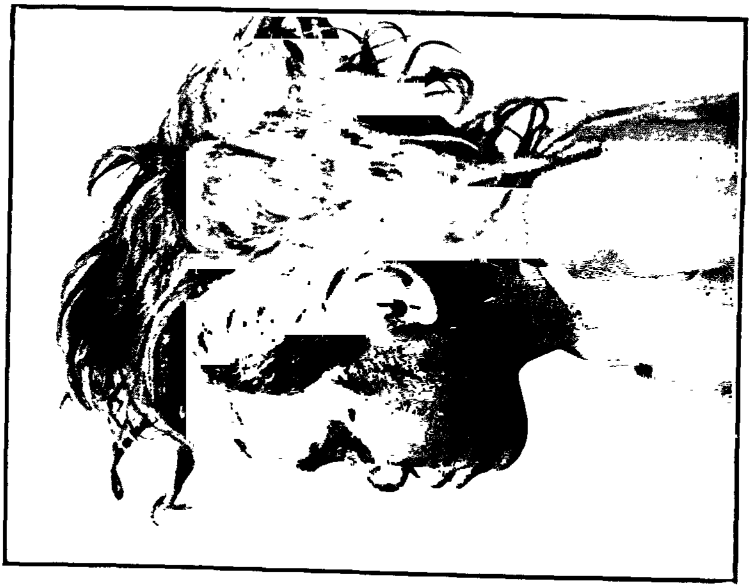

FIG. 8.—KAITISH GIRL, CENTRAL AUSTRALIA.

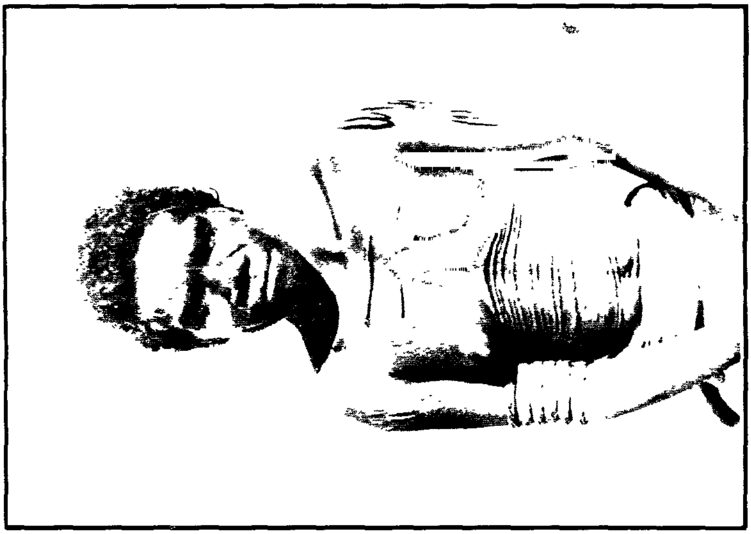

FIG. 9.—BINBINGA WOMAN, GULF OF CARPENTARIA.
(For Fig. 10 see page 61.)

FIG. 11.—PREPARING FOR A CORROBOREE. ARUNTA TRIBE.

FIG. 12. A CORROBOREE, ARUNTA TRIBE.

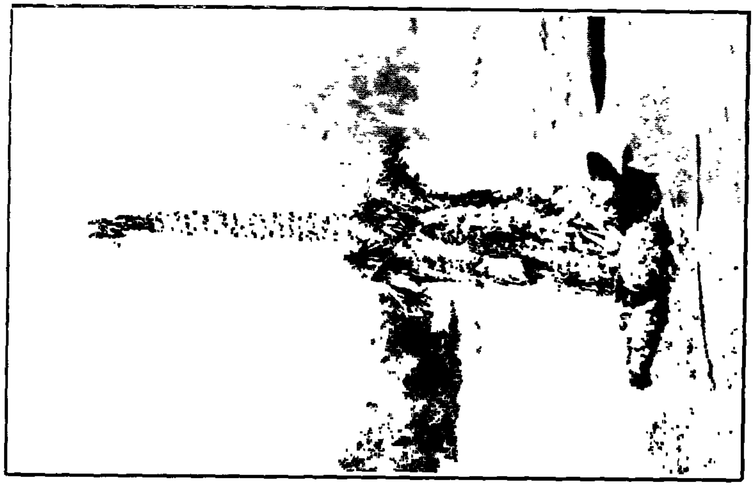

FIG. 13.—MAN DECORATED FOR CEREMONY OF FROG TOTEM, ARUNTA TRIBE.

FIG. 10.—ELDERLY WOMAN, WARRAMUNGA TRIBE, CENTRAL AUSTRALIA.

FIG. 14.—CEREMONY OF WITCHETTY GRUB TOTEM—ARUNTA TRIBE.

FIG. 15.—PERFORMANCE OF TRITCHINNA CEREMONY OF SNAKE TOTEM, URABUNNA TRIBE, LAKE EYRE.
The bone is passed through the skin of the right arm.

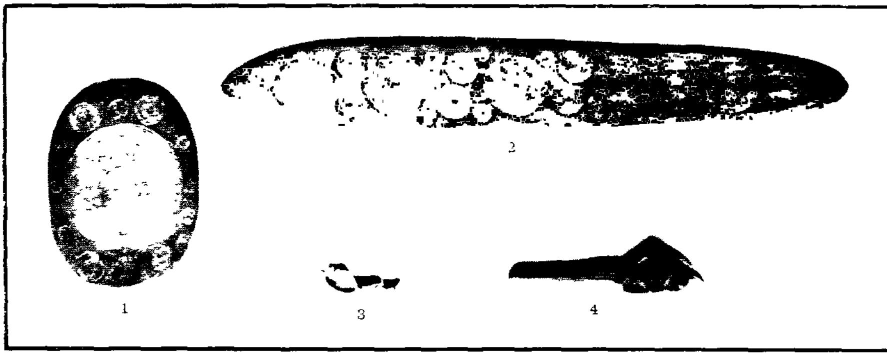

FIG. 16.—1. STONE CHURINGA. 2. WOODEN CHURINGA. 3. OPOSSUM LOWER JAW WITH INCISOR TEETH, USED FOR GRAVING. 4. OPOSSUM JAW HAFTED TO FORM A GRAVING TOOL.

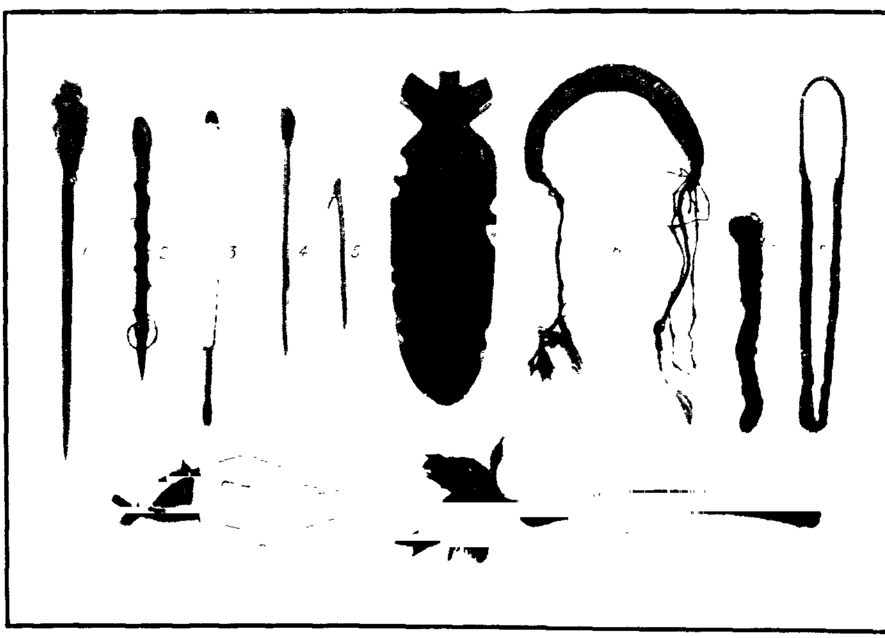

FIG. 17.—OBJECTS OF MAGIC—1, 2, 3, 4, 5 VARIOUS FORMS OF POINTING BONES AND STICKS. 6, 7, 8, NECKLETS CONTAINING HAIR CUT FROM A DEAD MAN. 9, BRET, A DEAD HAND, WHICH VIBRATES TO INDICATE APPROACHING DANGER—KURNAI TRIBE. 10. DEAD MAN'S ARM BONE, USED ON AVENGING EXPEDITION. 11. TIKOVINA, WORN DURING FIGHT BY THE NATIVES OF THE HERBERT RIVER, QUEENSLAND.

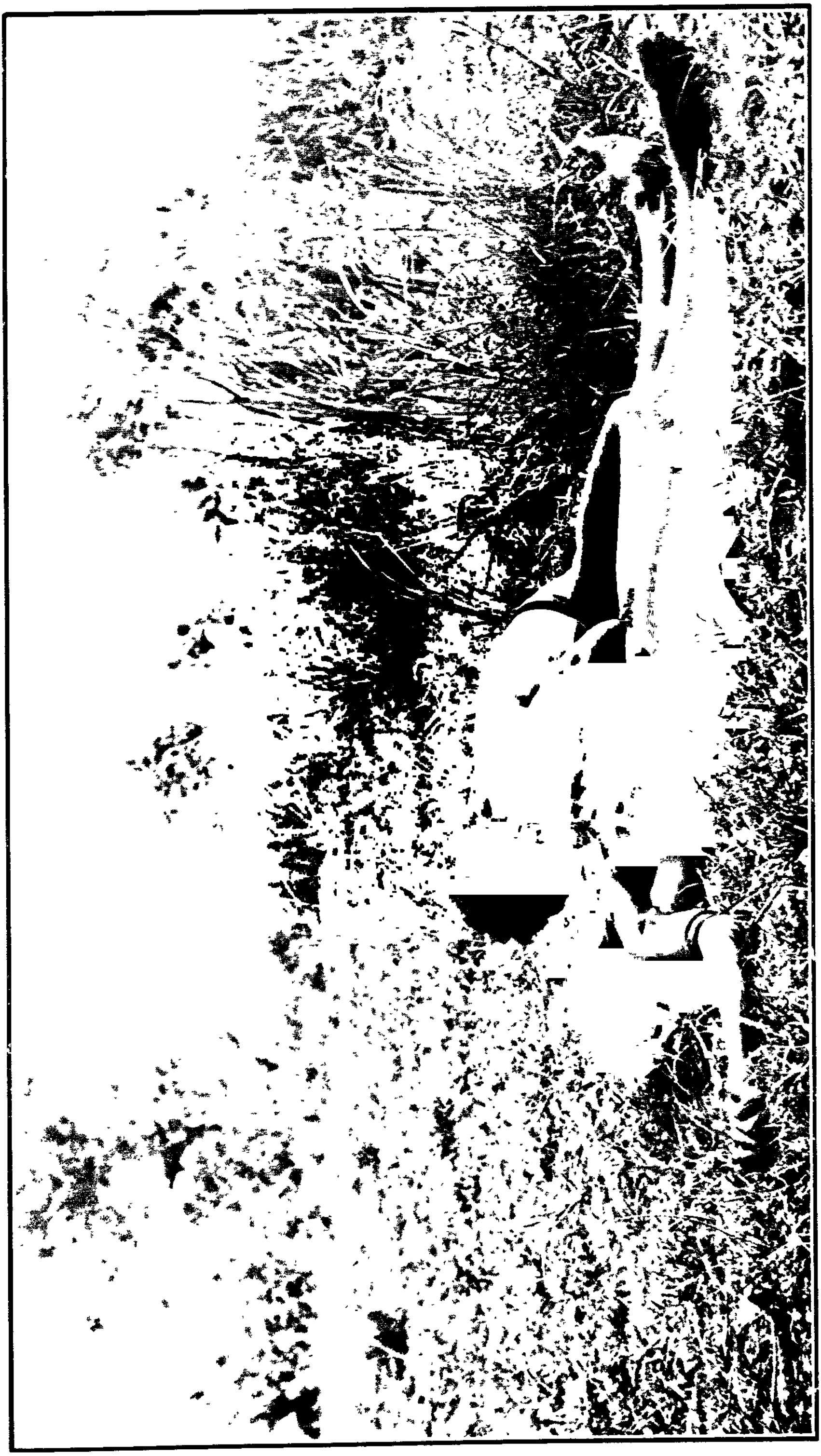

Fig. 18.—Medicine Man extracting Evil Magic from a Patient—Kakadu Tribe, Northern Territory.

FIG. 19.—CAPTURING A MAN'S SPIRIT "DOUBLE" BY MAGIC—KAKADU TRIBE, NORTHERN TERRITORY.

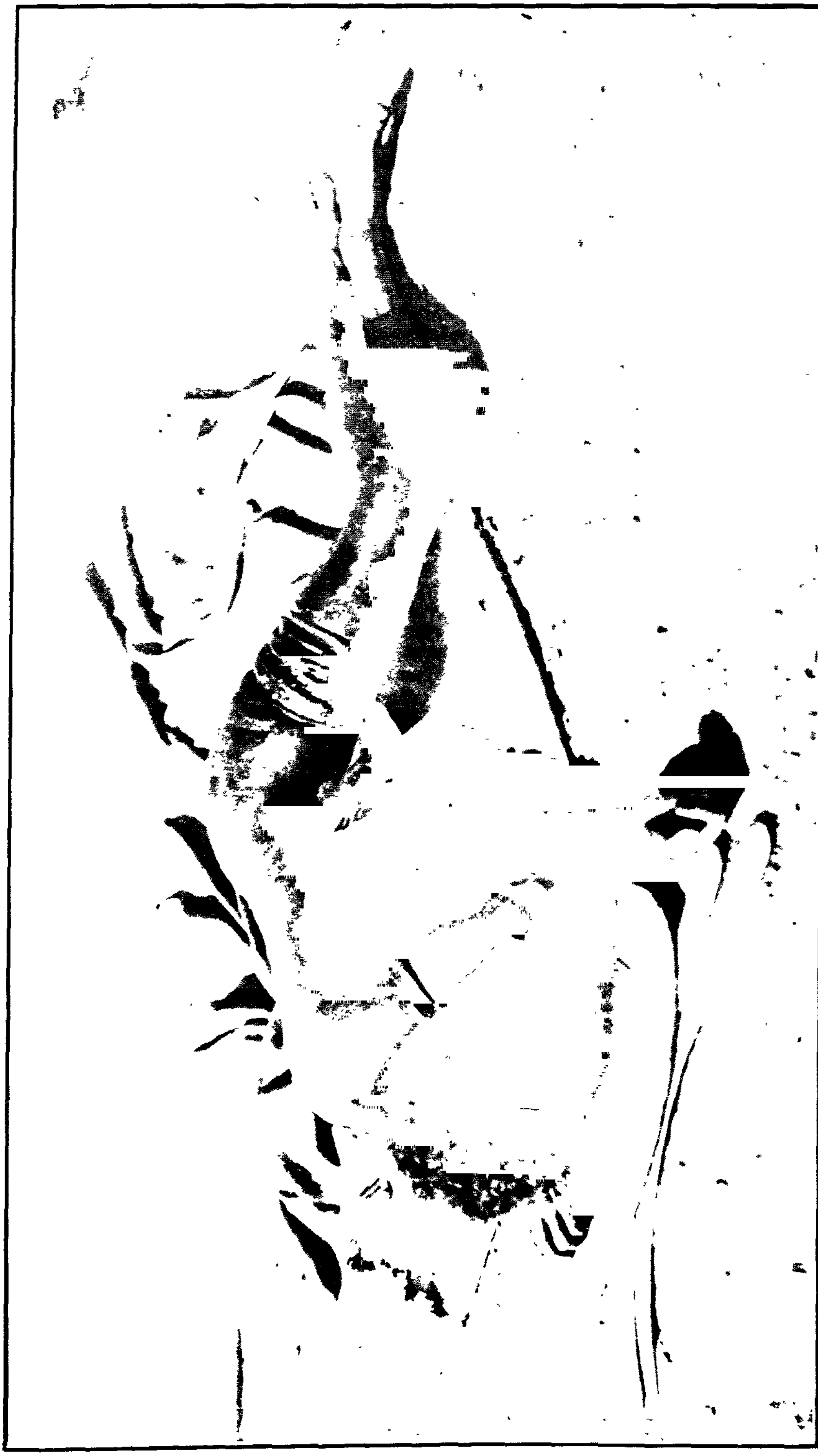

FIG. 20.—MAN WITH THIGH GASHED DURING A BURIAL CEREMONY—WARRAMUNGA TRIBE, CENTRAL AUSTRALIA.

FIG. 21.—TREE BURIAL. RAKING THE BONES FROM THE PLATFORM—WARRAMUNGA TRIBE, CENTRAL AUSTRALIA.

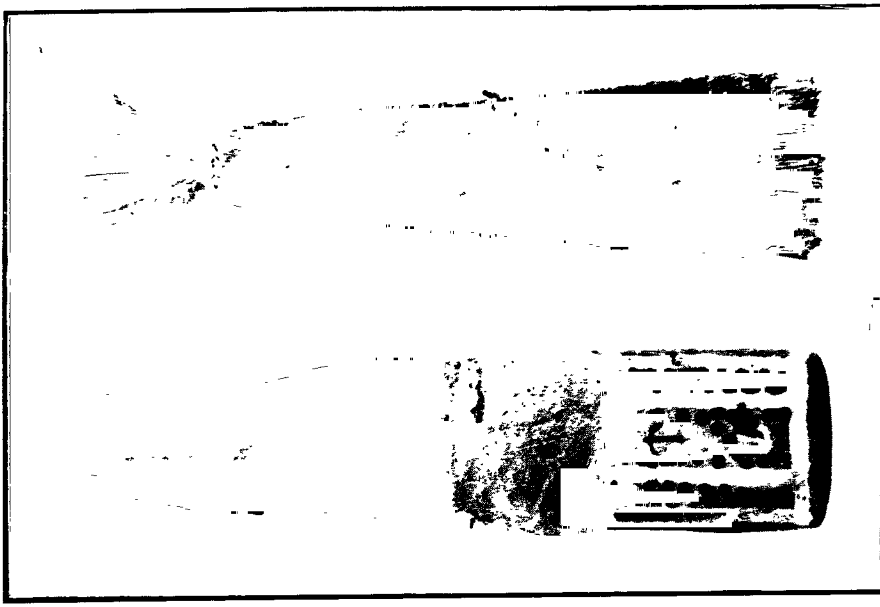

FIG. 22.—FLAKED KNIFE WITH RESIN AND WOOD HAFTING, AND CASE TIPPED WITH INVERTED EMU FEATHERS.

FIG. 23.—FLAKED AND CHIPPED PICKS, CENTRAL AUSTRALIA.

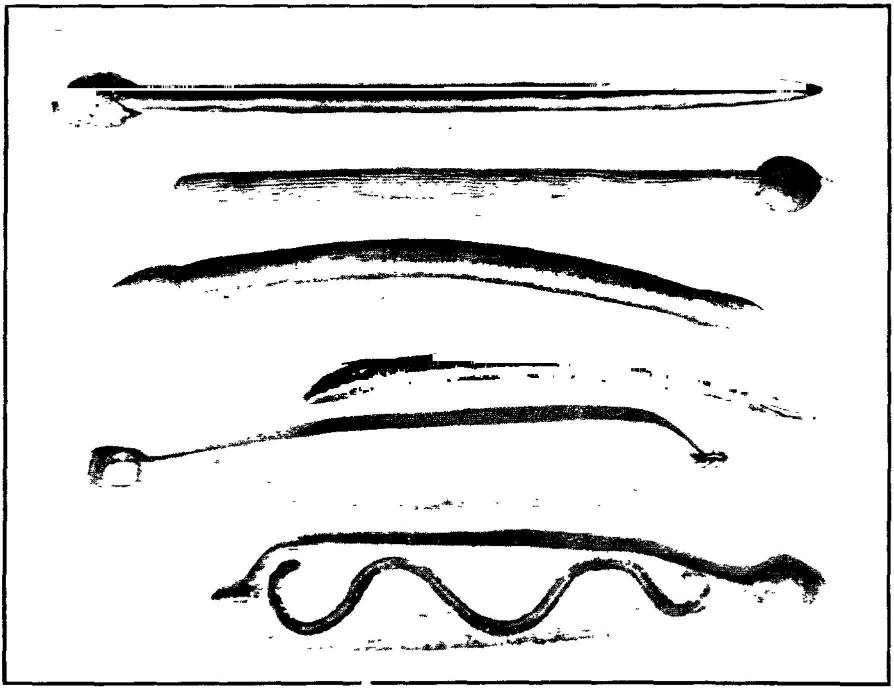

FIG. 24.—IMPLEMENTS WITH CUTTING FLAKES—1, 2, 3, 4. GOUGES OR ADZES. 5, 6. SPEAR THROWERS—CENTRAL AUSTRALIA.

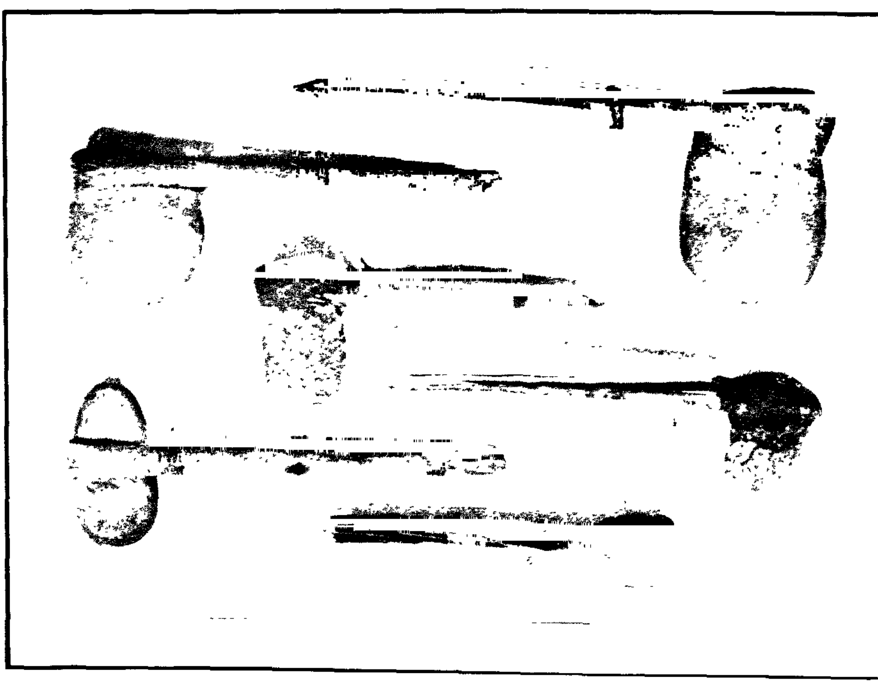

FIG. 25.—GROUND AND HAFTED STONE AXES—1, 2. WARRAMUNGA TRIBE, NORTHERN TERRITORY. 3, 4. KAKADU TRIBE, NORTHERN TERRITORY. 5. NEW SOUTH WALES. 6. QUEENSLAND.

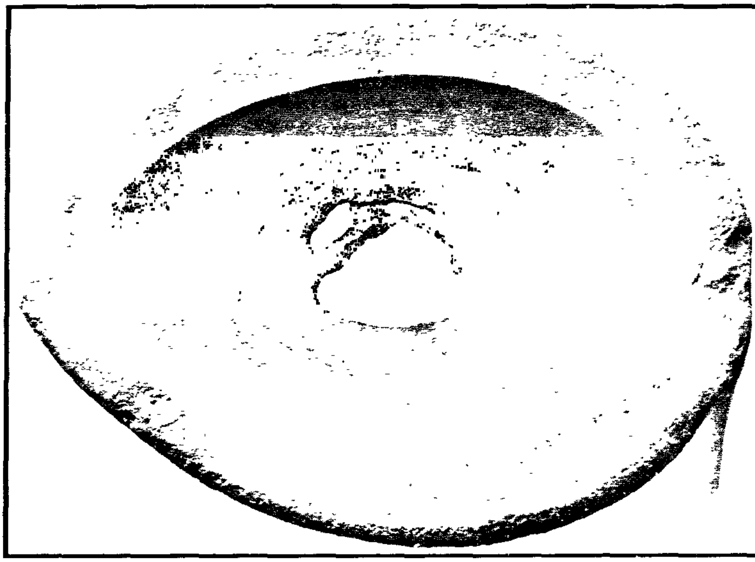

FIG. 26.—GRINDING STONE—NEW SOUTH WALES.
(This stone has been used for grinding on both sides.)

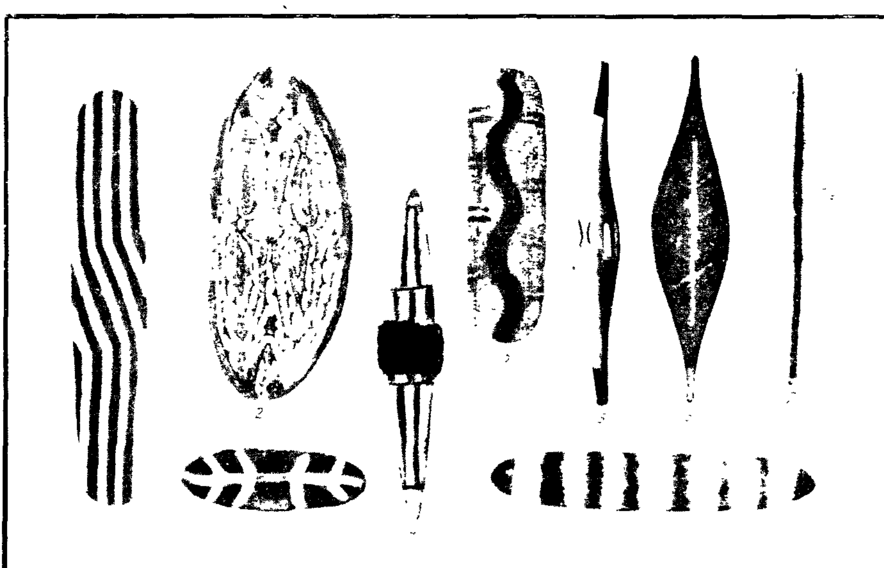

FIG. 27.—SHIELDS—1. WEST AUSTRALIA. 2. CARDWELL, QUEENSLAND. 3. CENTRAL AUSTRALIA. 4, 5, 6, 7, 8, 9. INTERIOR OF NEW SOUTH WALES.

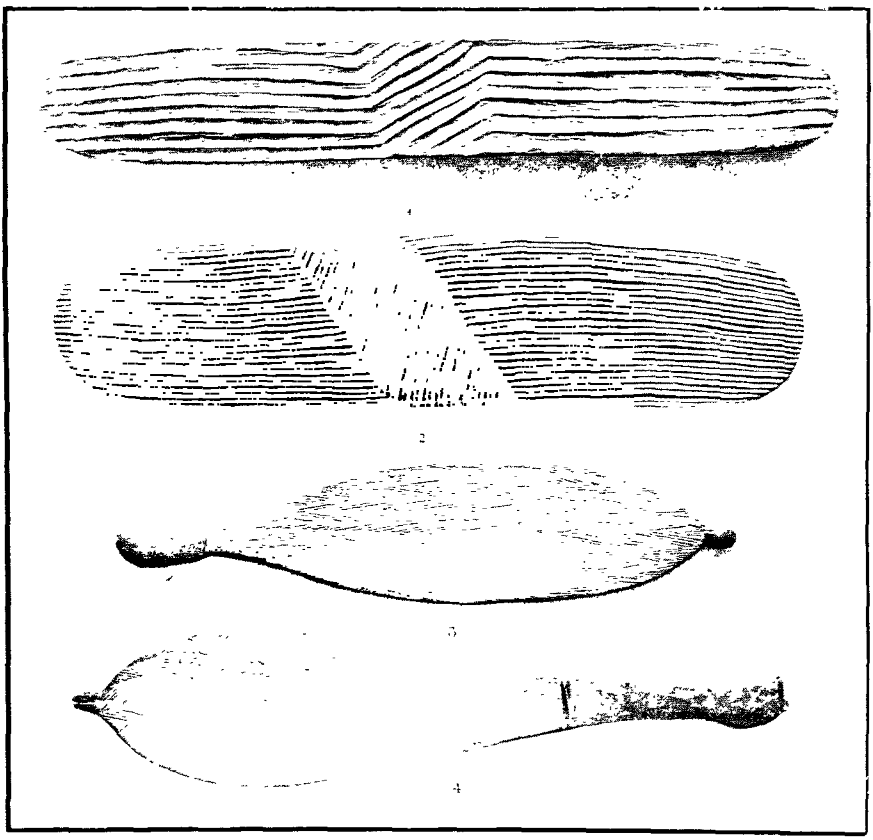

FIG. 28.—WESTERN AUSTRALIAN SHIELDS AND SPEAR THROWERS.

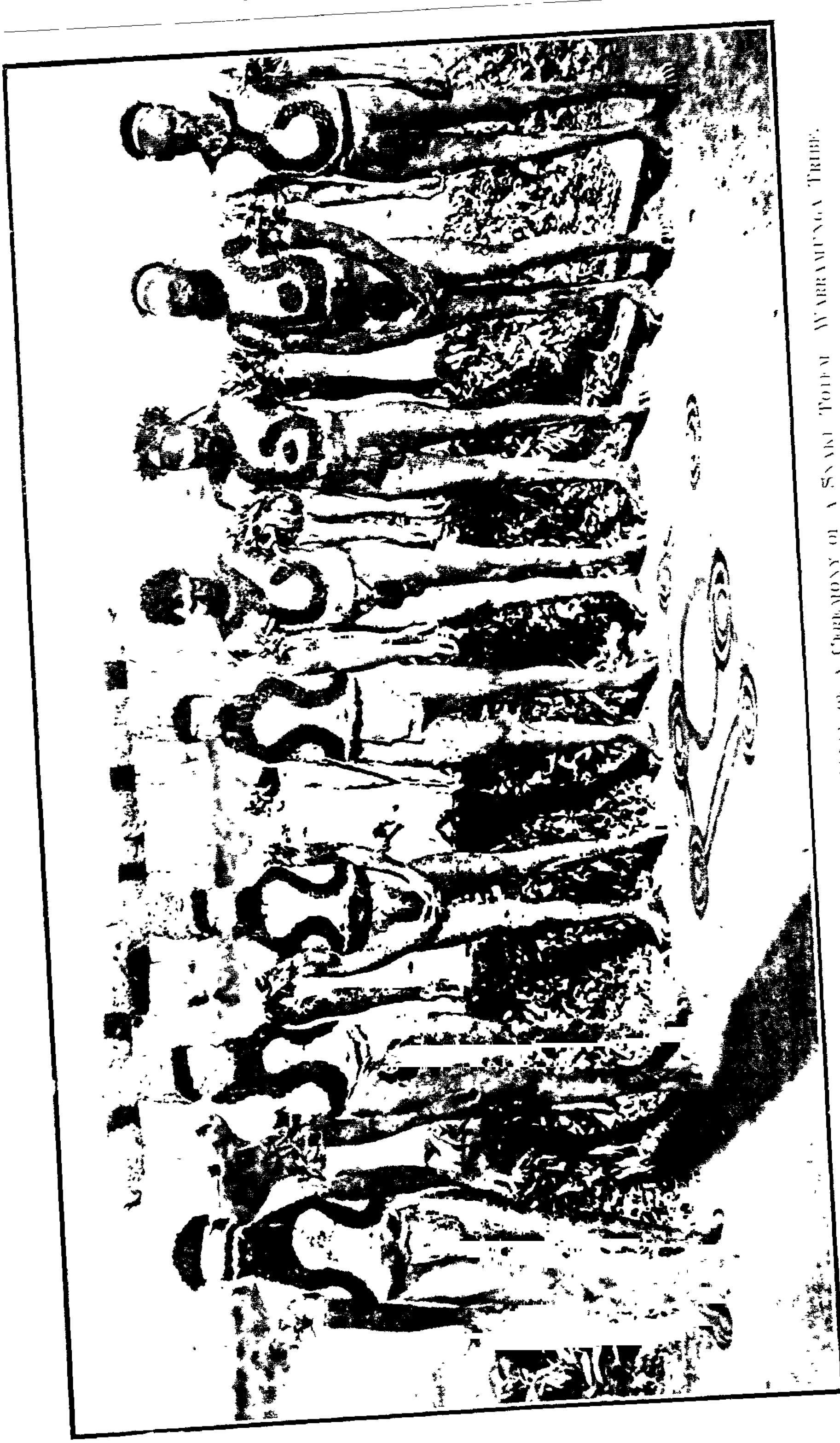

Fig. 29.—Designs used during the Performance of a Ceremony of a Snake Totem. Warramunga Tribe.

FIG. 30. GROUND DRAWING IN CONNEXION WITH A CEREMONY OF A SNAKE TOTEM WARRAMUNGA TRIBE

(Fig. 17). It is filled with magic. The body is buried in the ground in a sitting position with the knees doubled up against the chin, the earth being piled up to make a low mound with a depression on one side to allow of ingress and egress of the spirit. The camp is burnt down and in the case of a woman everything is destroyed. No person may mention the deceased's name during the period of mourning: if any one does, the spirit hears, thinks they are not mourning properly and is angry. No elder brother, father, mother, elder sister, father's sister, wife's mother, wife's mother's brother, father's brother, mother's sister, husband's mother, or husband's mother's brother may ever mention the name. In the case of a man, those who might legally be his sons-in-law neither mention the name, attend the funeral, nor take part in the ceremonies, but they must cut their shoulders. The actual widow or widows paint themselves with pipe-clay, and are called *Inpirta*, which means "the whitened one." To remove the silence ban a widow gathers seed, places it in a vessel, summons the other women and with them goes to the centre of the encampment, where they all sit down and wail. The sons and younger brothers approach, take the vessel in their hands, and shout "wah, wah," the widow joining in. The vessel, after being held close to the widow's face, is taken away by the men, who strike their shields on the ground in front of the widow, who may now speak. The ceremony shows that she is about to resume her ordinary life. Later on she will become the wife of one of the younger brothers. At least a year after death the ceremony of Urpmilchima—"trampling the twigs on the grave"—is performed. The widow smears herself over with pipe-clay and, wearing a chaplet made of clusters of small bones that hang down over her face, accompanies the other men and women first to her late husband's camp and then to the grave, which they approach yelling, so as to drive the spirit ahead and into the ground. After much cutting and wailing, the chaplet is broken and buried in the grave, by the side of which the widow rubs the pipe-clay off and her mourning is over. The spirit sees that it has been properly mourned for and returns to its ancestral home, where it lives until it undergoes reincarnation.

In the Warramunga, the body is placed on a platform of boughs in a tree (Fig. 21). When the bones are clean they are all raked out, the skull is smashed and, with the exception of one arm bone, they are buried in an ant hill. The arm bone is brought into camp and handed over to a mother of the dead person. Finally it is broken in two at the close of a ceremony connected with the totem of the deceased and buried in the ground.

In the Boulia district in Queensland, the body is buried in the ground, placed lengthwise on its back. Logs are laid on it, the earth filled in, and a small circular mound, 3 or 4 feet high, of logs, earth, stones and leafy branches is built; the ground around being cleared. The men and women cut themselves and, on return to camp, plaster their heads over with pipe-clay and paint the upper part of their bodies.

In the Mara, Binbinga, and other tribes on the west side of the Gulf of Carpentaria, the body is first of all placed in a tree. When clean, the bones are brought into camp and placed in a coffin made of a hollow log, ornamented with a design emblematic of the totem of the deceased. This is then

deposited by the side of a lily pool and is supposed to make the lilies grow. In these, and many other tribes, the flesh of a dead person is eaten; in most cases, probably by certain relatives.

On Melville and Bathurst Islands the body is buried in the ground. At a later period, grave posts, to the number of twelve or more, are erected at intervals of time. The natives gather together and, after dancing round a fire at which they must singe themselves, they rush to the grave, throwing their spears ahead to drive the spirit on and down into the ground. Then they perform dances around the grave posts, in which men, women and children take part, after which the spirit is supposed to remain quiet.

In every case there are certain individuals who must paint themselves so as to be prominent, the idea evidently being that the spirit will see them and recognise that it has been properly mourned for. In most cases also the women, such as widows and sisters of the dead man, are not allowed to speak for a certain period after the death.

9. Weapons and Implements.

(a) Stone Implements.

In 1891, Mr. R. Etheridge published the outline of a classification of stone implements,* and during recent years Mr. A. S. Kenyon has very largely extended the scope of the work.† It is not too much to say that at the present time we can parallel amongst Australian stone weapons all the types known in Europe under the names Chellean, Moustierian, Aurignacian, etc. We also have the great advantage that we can still, in some of the far back parts, though very rarely now, see the natives making and using their stone implements. The terms Eolithic, Paleolithic, and Neolithic, do not apply in Australia as indicating either time periods or levels of culture. Natives, not only in different parts of Australia, but in the same part, will use contemporaneously implements that, if they were found in prehistoric deposits, would be regarded as belonging to different stages of culture. Everything is, in the main, a matter of the material available. If the native lives in quartzite country, he makes chipped or flaked implements, some coarsely manufactured for temporary use, others carefully and often beautifully shaped. If he lives where he can get diorite, then he grinds his tools; and, if he lives where he can get material suitable both for grinding and flaking, then he makes tools which if found "fossil" would be called either Paleolithic or Neolithic; the rougher ones, indeed, would be called Eolithic or rejected as non-human by those who have never seen a native using a pebble that he has very roughly flaked to serve some temporary purpose. When they are in camp, for example, performing their ceremonies, some of which require the cutting of a vein, a man will simply take from the ground any pebble that lies handy, and with another will strike off little flakes until he secures one with a sharp edge and with this will cut his vein open. If at the present day a European archaeologist were to search amongst the belongings of, say, a Warramunga man in Central Australia, he would, unless prepared for it, be astonished to find that the native possessed, and continually used, a ground stone axe, a flaked or perhaps chipped and flaked

* Kenyon and Stirling. Proc. R.S. Vict., 1901, Pt. 2, p. 191.
† R. Etheridge, Jr. Proc. Linn. Soc., N.S.W. Vol. VI, Pt. 3, 1891, p. 357.

axe or pick, a flaked knife, hafted with resin or with resin and wood, and, at the same time, chipped stones quite as rude as, and indeed indistinguishable from, those of the old Tasmanians. It is this constant mixture of implements, usually regarded as belonging to different levels of culture, that forms the most striking feature of the present stone age in Australia. The nature and form of the implements is not a question of the stage of culture, but depends primarily upon the material available.

Without going into detail it may be said that the stone implements of the natives may be divided into three groups.

(1) *Cutting Implements.*

(*a*) Cutting edge produced by flaking or chipping, or both.
(*b*) Cutting edge produced by grinding.

These include axes, knives, adzes, and spear heads. On the one hand, they vary in form from the crudest chip or pebble, roughly flaked on one side so as to form an axe, to the delicate, leaf-like, jasper spear heads, indistinguishable from those made by the most highly cultured Neolithic people in Europe. On the other, they may be roughly chipped pebbles or blocks of stone, just showing the faintest trace of grinding, or they may be beautifully ground and polished with a keen sharp-cutting edge. It is, however, only in very exceptional cases that the whole surface is ground. In some cases they may be held in the hand and show a well marked "finger grip," but in others they may be hafted with the aid of resin and wood in various ways too detailed to describe here (Figs. 22, 23, 24, 25).

(2) *Grinding Implements.*

These may take the form of large kerns or mills, the nether stone being formed of a slab of sandstone hollowed out, often on both sides, with continuous grinding until the central crust becomes so thin that it breaks through: in some cases, as for the purpose of grinding ochre, any flat stone may be used (Fig. 26).

(3) *Pounding Implements.*

These take the form of lower stones or pestles, always with a pounding or husking hole, and of upper stones used as hammers.

In addition to these main groups we may add another—

(4) *Miscellaneous.*

These includes such objects as playing stones, sinkers attached to nets, etc.

(b) Weapons and Implements other than Stone Ones.

It would be futile to attempt more than the merest sketch of a description of these. They can be seen in the museum collections and attention is drawn here only to certain characteristic implements and features concerned with them. The most characteristic weapon is the boomerang, which does not appear to have been known to the Tasmanians. There are various forms of the implement, some, large and heavy, being used for fighting at close quarters, others for fighting and throwing at game, and others, often called

play boomerangs, that possess the characteristic feature of returning to a skilled thrower. There is a remarkable resemblance in the general form between a boomerang and the long, thin, curved leaf of many Eucalyptus. The missile always consists of a flattened curved blade, usually flat on one side and slightly convex on the other. The property of returning appears to be associated with a very slight twist, the weapon rotating during its passage through the air. A skilful thrower can make one describe first a large circle and then one or two smaller ones before it falls at his feet. It must be remembered, however, that the return boomerang is only met with in very restricted areas in Australia. In many, the curve is a wide open one, but there are all grades between a very slight curve and one in which the blade is divided into two parts almost at right angles to one another. In some cases, one end of a boomerang is fashioned to serve as a handle. Starting with an ordinary round, straight, throwing stick, a series can be traced leading up through a curved throwing stick, circular in section, to one elliptical in section, then on to a throwing stick slightly flattened and so to the ordinary curved boomerang with one side flat, the other slightly convex. From this typical weapon we can branch off along three lines, one leading to the highly specialized "return" boomerang, a second to a boomerang with one end slightly enlarged, and so on to the curved club-like missile called "lil-lil" and to the "beaked boomerang," while a third line leads through one of ordinary size, with one end fashioned to form a handle, on to the unwieldy so-called "sword" met with in Queensland.

There are endless varieties of clubs and spears, all made of wood, with, in the case of the latter, barbs or blades of wood, bone, or stone. Most of them have a concavity at the handle end, into which fits the knob of a spear-thrower, but both the very light cane ones, with simple sharp wooden points, and the great javelins of the Melville Islanders, are thrown by the hand. The spear-thrower is a very characteristic Australian weapon. It may be only a rounded stick with a knob of resin at one end, 2 or 3 feet long, or it may be leaf-shaped and either flat or decidedly concave, and used for other purposes as well as throwing. The Arunta thrower has a small wooden knob at one end, tied on with sinew, and at the handle end a lump of resin, into which is fixed a sharp, cutting flint. During ceremonies, it serves to hold a supply of blood, down and ochre; at other times it serves as an adze, gouge or chisel. Altogether it forms one of the most useful implements that the native has.

Some of the most ingenious and useful implements are wooden troughs or pitchis and baskets that are used for carrying food and water. The former are fashioned out of solid logs cut from gum trees, or, when such is available, from soft wood, such as that of the bean tree. The perfect symmetry and shape of the hardwood troughs and the regularity with which the concave lines, made by the cutting flint, run parallel to one another along the length of the trough is wonderful. The simpler baskets may be made out of palm or pandanus leaves, or sheathing stalks ingeniously folded over. Others are made from sheets of stringybark, stripped from a gum tree during the wet season. Others, again, are made of plaited grass or of string, so closely netted that the bags will hold fluid. The most remarkable baskets

are undoubtedly those made from split cane, with the two lower ends pointed and upturned. The symmetry of these, which are only made in Queensland, is extraordinary.

Shields vary much (Fig. 27). They may be made of soft or hard wood and the handle carved out of the solid or inserted separately. For the most part they are broad, but, in the south-east of the continent, a narrow one was used to ward off the blows of clubs. The surface of the shield lends itself to decoration. Sometimes this takes the form of incised patterns, but, more often, apart from the concave lines made by the flint, the design is due to pigment. Attention may be drawn to the massive shields with bold design, found only in parts of Queensland.

The native is very clever in making string, for which purpose he uses human hair, fur of different animals, shredded leaves, such as those of the pandanus, or bark of different trees. He may simply use one hand to "serve" the material and the other to rub it on his thigh, or he may employ a very simple spindle. So admirably is the string made, that, at a casual glance, it appears just the same as a white man's, but it can be distinguished by the fact that native twine is seldom more than two-ply, while the white man's is seldom less than three. It is used for various purposes, the most important being, perhaps, the making of nets and bags. Some of the larger fishing nets measure 70 feet in length by 7 in width.

Clothing and ornament vary very much in different tribes. In the south-east and west of the continent kangaroo skins are used, sewn together and often decorated with coloured patterns on the inside (the fur being on the outside) to form very efficient rugs. In the central and northern parts, the only clothing consists of a more or less efficient apron, usually like a great tassel suspended from a waist girdle. In the very centre it degenerates in size and may, on the men, be more an ornament than a covering. It is remarkable that the central natives have not invented clothing, because kangaroos are often abundant and the nights in winter are bitterly cold. On Melville and Bathurst Islands the women wear an efficient apron made of paper bark, the men are stark naked. Ornaments in the form of head bands of flattened-out or netted strands of string, tufts of white cockatoo feathers, emu feathers, or waist girdles of gaily coloured parakeet feathers are often worn, and, speaking generally, it may be said that it is the men and not the women who usually decorate themselves.

10. Decorative Art.

The decorative art of Australian natives, so far as their weapons and implements are concerned, is generally remarkable for the almost entire absence of design suggested by natural objects. In south-eastern Australia we meet with shields, etc., ornamented with conventionalized animal drawings, but they are so uncommon as to attract attention at once. In his rock and bark drawings the native will depict animals and plants, but, for the most part, the ornamentation of implements and sacred objects alike consists of conventional designs. The Australian aboriginal appears to have been but little influenced, artistically, by his natural surroundings. Owing to lack of material, he is restricted to a few colours. Red ochre that can be mixed with pipe-clay to produce varying shades, yellow ochre and charcoal are his

three mainstays. Here and there he may have something like "wad," an oxide of manganese, that gives a pearl-grey colour when powdered. It is very doubtful if blue is ever used by the Australian in his native state, though he soon adopts it in contact with white men.

A very striking feature of his decorative art is the use that he makes of down derived either from birds or from the involucral hairs of different plants. He mixes it with red ochre or pipe-clay, never, curiously, with yellow. With the aid of such materials he produces simple, bold designs of circles, spirals, and symmetrically curved lines, showing an appreciation of strong contrasts, such as are offered by black or red circles, spiral and curved bands outlined by white dots. So far as the nature of the designs is concerned, we can divide them into three series—zoomorphs, phytomorphs, and geometrical. From another point of view, they may be divided into two series—first, what we may call ordinary, and, secondly, sacred designs. We will deal with them under these two aspects.

(a) Ordinary Designs.

In regard to the method of production of these, there are three well-marked types.

(1) Incision by means of a Sharp Stone, Tooth, Bone, or Shell.

The simplest ornamentations have the form of finer or coarser groovings that run parallel to the length of implements, such as pitchis, shields, and boomerangs. These do not necessarily give rise to a pattern. In olden days the tribes on the Murray River and in various parts of the coastal districts of New South Wales and Victoria made very elaborate shields with incised designs representing animals. Their spear-throwers were ornamented in the same way. Very characteristic, indeed, is the zig-zag incised pattern on Western Australian shields and spear throwers (Fig. 28). In some cases concentric squares are cut on weapons and corroboree tablets. In some parts of Australia, more especially in New South Wales, trees near to a grave were ornamented on one side or all round, for many feet from the ground, with deeply cut designs, some of which may, perhaps, be totemic in significance. Occasionally incised drawings are made on rocks, as in the case of the large drawings of animals described by Mr. Etheridge on the coast near Sydney.

(2) Burning the Surface with a Fire-stick.

This is not a frequent form of ornamentation, and is only used in the case of "pointing sticks." In the central area it is very characteristic of these. It takes the form of a series of spiral lines, circles, notches, or dots.

(3) Painting a Surface with Pigment.

This is by far the most common method of ornamentation, and may be treated under three heads—(*a*) drawings on weapons and implements (*b*) drawings on human bodies, and (*c*) drawings on the ground, rocks, and bark.

(*a*) In many cases it is customary to coat almost every weapon with ochre. In some cases, weapons, such as boomerangs, shields, spears, dilly-bags, knives, and fighting clubs have special designs. It would be tedious to go

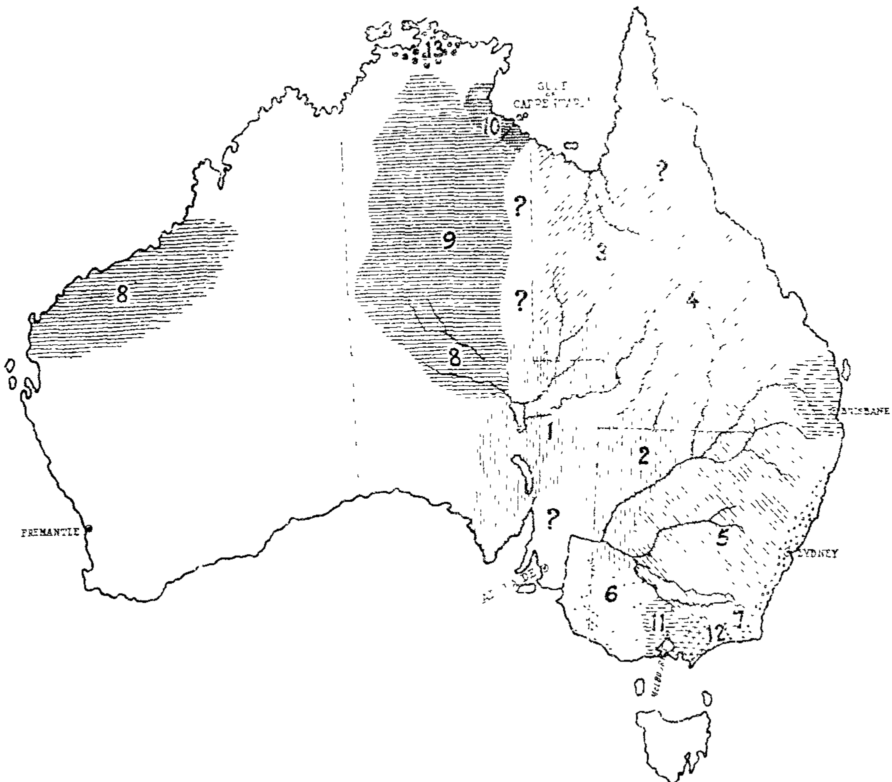

FIG. 31.

MAP OF AUSTRALIA SHOWING APPROXIMATELY THE DISTRIBUTION OF THE VARIOUS GROUPS OF TRIBES.

1. Tribes with Maternal Descent and the moiety names Kilara and Marteni or their equivalents.
2. Tribes with Maternal Descent and the moiety names Mukwara and Kulpara or their equivalents.
3. Tribes with Maternal Descent and the moiety names Utaru and Pakuta or their equivalents.
4. Tribes with Maternal Descent and the moiety names Utaru and Maieru or their equivalents.
5. Tribes with Maternal Descent and the Kamilaroi organization.
6. Tribes with Maternal Descent and the moiety names Gamutch and Krokitch.
7. Small group of Tribes with Maternal Descent and moiety names which were said to stand for Eaglehawk and Crow. Very little was known of them before they became extinct.
8. Tribes with Paternal Descent and the southern Arunta organization. They probably extend right across the centre and over a much larger area of West Australia than indicated.
9. Tribes with Paternal Descent and the Warramunga organization.
10. Tribes with direct Paternal Descent and the Mara organization.
11. The Kulin group of Tribes with Paternal Descent and the two moieties Bunjil and Wang.
12. The Kurnai Tribe with Paternal Descent.
13. The Kakadu group of Tribes with no class organization.

into detail and the reader is referred to the works of Etheridge, Roth, Stirling, Spencer and Gillen, Brough Smyth, and others. Attention may, however, be drawn to the zig-zag designs of Western Australia, to the bold decorative schemes on the large Queensland shields, to the carefully drawn designs on Queensland dilly-bags, where conventional designs are sometimes associated with zoomorphs, and also to the very characteristic and effective designs on the spears, throwing sticks, grave posts and, more especially, the large bark baskets of the Melville and Bathurst Islanders. The latter are different from any on the mainland. The various designs indicate considerable variations in artistic skill, but they all show that the native has a very distinct feeling for decorative effect.

(*b*) The drawings on human bodies are done in red and yellow ochre, pipe-clay, charcoal. In some cases the designs are merely what the natives call "play-about," but the more important are associated with the performance of corroborees. In almost all cases these are purely conventional designs of circles and lines that often follow the contour of the body. Each corroboree has its own design (Figs. 11 and 12).

(*c*) The drawings on rocks and bark are some of the most interesting and vary much. They may be zoomorphic, phytomorphic, or purely conventional designs, such, for example, as those from Central Australia described by Dr. Stirling, though the first two are more common than the third. In one of the zoomorphic ones, the spectator is supposed to be looking upwards from beneath an emu that is sitting on its eggs; in others we have drawings of wild dogs, kangaroos, and various animals; in others, of cycad fronds, while others are purely conventional, consisting of concentric circles of lines and dots. The "red hand," about which so much has been written, has no special significance. It is met with everywhere and is made by placing the hand on a rock or bark surface, and then silhouetting it by means of blowing red ochre on to the rock around it. Sometimes pipe-clay or charcoal is used, in which case we get, respectively, a white or black hand but in no case, red, white, or black, has it any more significance than the outline of a fern made by a child squirting ink over the leaves. In some cases, and more especially on the northern coastline, fairly elaborate drawings of animals and mythical objects are made on rocks or sheets of bark. The walls of rock shelters are covered over with often very suggestive, though crude, representations of the animals the natives feed upon—crocodiles, lizards, snakes, fishes, etc.—and sometimes also with quaint drawings of gnomes that inhabit the mangrove swamps and rocky ranges. By far the most elaborate rock paintings, however, are those first described by Grey, and later by Brockman, in the Kimberley district. They are, apparently, made by natives, but, in regard to the presence of clothes, etc., clearly show outside influence

(b) Sacred Designs.

In many cases, at first sight, these are not distinguishable from some of those already described, in fact, so far as conventional drawings such as concentric circles are concerned, as much depends on the location of the drawing as on its nature. In one spot a drawing will be sacred, in another it will not, but, whilst this is so, yet, on the

whole, the sacred designs are well defined. They are best known in the central and northern tribes, amongst whom they are very well developed. In the Arunta, for example, every totem group has its *Ilkinia*, or totem design, which the men of the totem group may paint on themselves. In addition to this, right through the tribes, every separate totemic ceremony has a special design painted on the bodies of the performers, consisting of lines of red and white down that often closely cover the whole of the upper half of the body and face and extend upwards on to an elaborate headdress (Fig. 29). In every instance, the down is fixed on the body by blood drawn from the performers. The illustrations will give an idea of what these designs are like. In addition to them, some totemic groups have special designs drawn on rocks at places where churinga are stored and ceremonies performed. No women go there. Others have ground drawings of a very elaborate kind that can be best exemplified by the Wollunqua snake totem in the Warramunga tribe. Two of these will suffice. In one the sandy soil was smoothed down with water to make a firm flat surface, over which a coating of yellow ochre was spread. On this, five series of concentric circles were drawn, representing trees and water holes at the home of the Wollunqua. An 18-ft. long, sinuous band represented the snake itself, and footmarks by the side indicated those of an old man, its mate. The rest of the design consisted of white spots of pipe-clay that entirely surrounded the black bands. The main features were laid down by one old man, who drew the circles and sinuous line, using two of his fingers as a brush, without any mechanical aid. This done, he retired, and the drawing was completed by younger men (Fig. 30). In the other, a mound, 15 feet long and 18 inches high, was made. It was covered with dots of pipe-clay that surrounded and outlined a sinuous band of red ochre along each side, representing the snake. Ground designs similar in significance, associated with sacred ceremonies, now exist, or once did, amongst many tribes on the eastern coast.

Some of the more elaborate designs are those on objects worn or carried by men performing sacred ceremonies.* One such special object may be described, partly because it represents one of the most elaborate, and partly because the significance of its different constituents gives a good idea of one side of the native mind. It is called a Waninga, and is, or was, used in tribes round Lake Eyre, such as the Urabunna, and also in the southern Arunta. First of all, it is important to note that a Waninga used in a kangaroo ceremony, for example, represents a kangaroo, while a similar one used in a rain ceremony represents rain and things associated with it. To take a rain one: A strong spear, 10 feet long, forms a central shaft; at right angles to its length and at a distance of 2 feet from either end, are two sticks, each 3 feet long. Between the two, running parallel to the length of the spear, lines of human hair string are tightly strung. Each line takes a turn round the transverse bar at either end, then slants away to the spear, turns round this and then runs back to the bar, until the whole space between the bars is filled with close set bands of string with a triangular-shaped patch at each end. A band, 1½ inches wide, running round about the same distance within

* As colour forms a very important element in these it is impossible to describe them adequately in words. A coloured plate of some of them, now in the National Museum, Melbourne, is given in "Northern Tribes of Central Australia," p. 722.

the margin, is made of opossum fur string, whitened with pipe-clay, the same width of string on the inside of it being red-ochered. Tufts of the red-barred tail feathers of the black cockatoo are tied to the tip of the spear and the ends of the bars. A number of bands of white down run in parallel lines across the strings. The man carrying the Waninga wears wood-parings on his head, smeared in blood. The red string represents thunder; the white band, lightning; the ordinary black string, rain falling; the white down, clouds. Black cockatoo feathers are used because the call of these birds is always taken as an indication that there is a waterhole near. The red of the feathers and the blood-smeared wood parings represent the masses of dirty brown froth that float on flood waters. This Waninga is used during rain-making ceremonies, and serves not only as a good example of decorative art, but of the exercise of sympathetic magic.

CHAPTER III.

THE PHYSICAL AND GENERAL GEOGRAPHY OF AUSTRALIA.

*By Griffith Taylor, B.Sc., B.E., B.A., F.G.S., Physiographer in the Commonwealth Bureau of Meteorology.**

SYNOPSIS.

1.—General Structure.

Australia, the smallest continent, lies to the south-east of the chief land-mass of the globe conveniently known as the Old World. Connected thereto by the partly submerged but high mountain ranges constituting the East Indian Archipelago it offers the strongest contrast to the latter in outline. In place of sporades of long narrow islands Australia presents perhaps the most unbroken outline of all the continents, and is certainly one of the lowest in elevation.

Both these features are probably due to one factor—the presence of a huge dense unmoving block in the earth's crust in the form of the West Australian horst. Against this comparatively low, resistant area the folding forces affecting the earth's crust have again and again advanced the crustal ripples to which most elevated land is due. Nor is it improbable that the massif itself in reaching equilibrium has exerted an outward puckering

* By kind permission of the Delegates of the Clarendon Press University of Oxford, the writer has abridged this account from his article in the forthcoming "Oxford Survey of the British Empire" to be published by that body. Mr. Taylor held the position of Senior Geologist in Captain Scott's Expedition.

In the absence of Mr. Griffith Taylor in England, this chapter has been revised by Mr. D. J. Mahony M.Sc., F.G.S., Geological Survey of Victoria.

force on the less solid sediments to the east. To this may be attributed the dominating direction of the north and north-west folds which occur in Australia, and which tend to lie in concentric lines about a centre near Cape Leeuwin* (see Plate V. in Chap. VII., *The Geology of the Commonwealth*). But, on the whole, Australia has been remarkably free from great folding forces in later geological times. Ordinary normal erosion by rivers and wind has been at work and has succeeded in wearing the greater portion of Australia to a uniform height of some 1,000–1,500 feet above sea level.

Broadly speaking, there are no large areas of Tertiary deposits in Australia except the ancient Murray estuary. Since Cretaceous times there can have been no very important alterations in the surface of Australia as we know it, though undoubtedly as regards outline it then extended very much further to the south-east and east than at present.

In position it is more isolated than any other large land mass excepting Antarctica. Taking as a standard of length the distance from London to Algiers (about 1,000 miles), the journey from Perth to Colombo is more than three times this unit; and the same huge distance lies between Hong Kong and Thursday Island in the north of Queensland. Indeed, Java is the only large civilized area which is within a thousand miles of any portion of Australia.

But Australia itself is a country of vast distances. It is 1,600 miles from Perth to Adelaide, the capital of the next State; while in New South Wales to reach its third town (Broken Hill) from the capital (Sydney) a railway journey of some 1,400 miles (*viâ* Melbourne and Adelaide) is necessary.

Australia, including Tasmania, has an area of 2,974,600 square miles approximately; and with the region of Papua (British New Guinea) which is administered by Australia, the total rises to about 3,065,100.

The arrangement of the elevated areas in Australia is in close concordance with the structural principles indicated previously.

Broadly speaking, Australia consists of three well-defined and contrasted areas—an ancient western plateau of 1,000–1,500 feet in height, and two eastern belts. The more central of these is a meridional belt of low-lying, level-bedded deposits (of Mesozoic age chiefly), while the eastern portion is a cordillera forming a fairly complete bulwark barring out the Pacific Ocean from the central plains.

(a) Regional Geography.

In Australia the political boundaries are pre-eminently artificial. With the exception of one or two natural lines of demarcation—such as the River Murray—no natural inland features have been utilized. In these circumstances it is felt to be preferable to consider the geography of Australia in terms of its chief natural regions, not in terms of the various States and Territories. Since the Commonwealth (with its unity of policy) was constituted, the various State railway systems are gradually being linked across the boundaries. For instance, note the delay in linking the

* This aspect of Australian physiography is treated in a masterly fashion by Professor David in his presidential address to the Royal Society of New South Wales, 1911. This should certainly be consulted.

Riverina to Melbourne. These have been hitherto perhaps the chief economic factors in maintaining State differences within the artificial boundaries determined by the Constitution.

Although Australia is a continent characterized by the slow change in the nature of its surface, by monotony in the flora and by vast uniform expanses of rolling grass land or more arid steppe, yet the larger States are so extensive that several types of environment occur therein and react each in its own way on the life and industries of the inhabitants.

The regions adopted in this account are the following:—

A. Eastern Cordillera fringing the Pacific and extending from Cape York to the Victorian Grampians and Tasmania.

B. The Murray–Darling Basin, a region chiefly below 1,000 feet, and extending from Bourke to the mouth of the Murray.

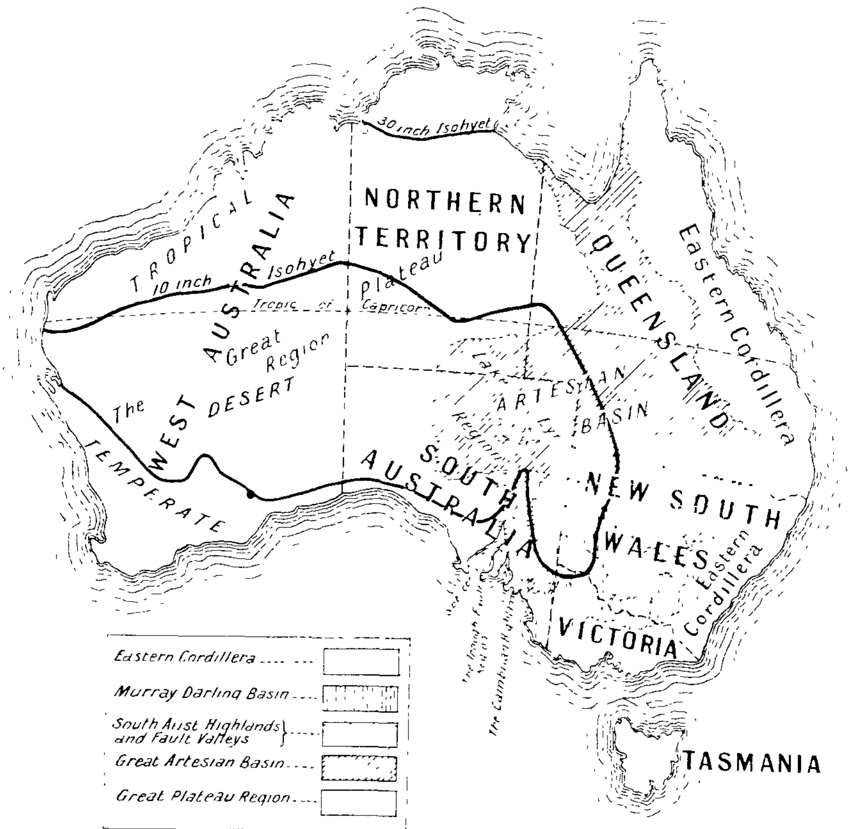

FIG. 1.—The Relation between the political and natural divisions in Australia.

C. The South Australian Highlands with their associated fault valleys, extending from Broken Hill to Port Lincoln.

D. The Great Artesian Basin reaching from the Gulf of Carpentaria to Lake Eyre.

E. The Great Plateau Region embracing the western half of the continent.

The political areas are built up as follows :—

Political	Natural Elements.	
	Lowlands.	*Highlands.*
Queensland.. .. (670,500 sq. miles)	Eastern section of Artesian Basin (D)	Northern section of Cordillera (A)
New South Wales, including Federal Capital Territory (310,372 sq. miles)	South-east portion of Artesian Basin (D); merging into the Murray–Darling Basin (B)	Central section of Cordillera (A)
Victoria .. (87,884 sq. miles)	Southern portion of Murray-Darling Basin (B)	Southern section of Cordillera (A)
Tasmania .. .. (26,215 sq. miles)	.. ..	Isolated portion of Cordillera (A)
South Australia .. (380,070 sq. miles)	Trough-faults to west of highlands (C). Western portion of Artesian Basin (D)	Highlands of Flinders Range, etc. (C). South-eastern portion of Great Plateau Region (E)
Western Australia .. (975,920 sq. miles)	. .. ..	Wholly comprised in the Great Plateau Region (E)
Northern Territory . (523,620 sq. miles)	The Gulf country (E)	Also provisionally classed with the Great Plateau Region (E)
Papua .. .. (90,540 sq. miles)	. .	An isolated northern portion of the Cordillera (A)

2.—The Eastern Cordillera.

Perhaps the dominant feature on most maps of Australia is the so-called *Great Dividing Range*. This belt of highland undoubtedly constitutes the divide between the coastal drainage and that flowing westward to Lake Eyre or the Murray Mouth. But if we examine it all closely it is seen to be in no sense a *range*, but is for the most part a series of disconnected elements of very diverse origin.

In Queensland it is only an important feature where formed of basalt-flows of comparatively late date. Between these it is often a mere warp-ridge but a few hundred feet above the general level.

In New South Wales in the north the Great Divide gets on solid ground for 100 miles, for here it runs along the great New England granite massif. But the Liverpool Ranges—quite a late geological formation—deviate it to the west. Here the Divide deteriorates to a mere water parting (at Cassilis) between the Goulburn and Talbragar Rivers, where the cutting action of the Goulburn has driven the Divide far to the west. The " range " is not 2,000 feet high hereabouts.

The Divide returns along the southern rim of the Goulburn Valley towards the coast, and then is carried southwards by a series of indefinite ranges, consisting here of basalt flows—there of recent folds ; and again, as at Cooma, with no apparent elevation at all. Hereabouts we notice that Lake George is perched right on the Divide ; while Merigan Creek flows right through the so-called Divide ! Near Cooma it enters on an extraordinary zig-zag path, which points to recent interruptions in the drainage. These zig-zags around the heads of the Snowy and Tambo Rivers are the results of important river captures. Finally, in Victoria, the great area of Pliocene basalt in

the west of the State has certainly flooded pre-existing lowlands and valleys and converted portions of them into the modern Divide.

Lying parallel to the modern Divide, and in the north considerably to the east of it, is another belt of highlands almost coincident with the coastline. These coast ranges are formed of an almost continuous series of granite masses

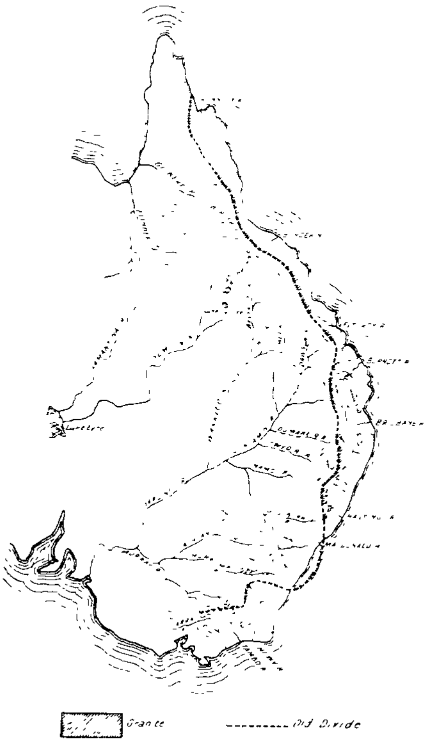

FIG. 2.—The Granite Areas of Eastern Australia, showing the agreement with the ancient pre-uplift divide. The probable arrangement of early Tertiary drainage is indicated.

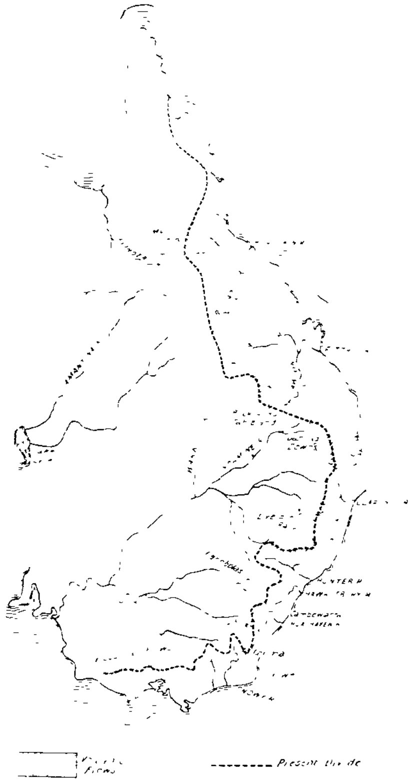

FIG. 3.—The later Volcanics of Australia, chiefly late Tertiary basalts, showing their association with the present divide.

which reach from Tasmania to Cape York. South of Queensland the modern basalt-capped Divide and the granitic masses are mingled to a greater degree. This broad "complex" of highlands of varying origin forms a fairly well-marked belt to which the name Eastern Cordillera is here applied.

The following subdivisions of the Eastern Cordillera are convenient:—

A. The Queensland Highlands.

B. The South-eastern Highlands, in New South Wales.

C. The Victorian Cordillera and its Coast Plains.

D. Tasmania.

(a) The Queensland Highlands.

General Physiography.—This is a belt of country about 150 miles wide, extending from Cape York to the New South Wales border. It possesses a fairly homogeneous structure. In the east, along the coast, extends a

belt of ancient granite ranges often pierced by deep gorges whence the coastal streams now reach the sea. Within this bulwark is a belt of later Palæozoic rocks (Devonian to Permian) which have been cut into by coastal rivers. Overlying these deposits on the west are later sediments of Mesozoic age. They have been subjected to gentle warping accompanied by volcanic outbursts in Tertiary times.

For some 1,200 miles the coast is flanked by the coral reefs of the Great Barrier. Its steep outer margin is some 30 to 75 miles from the coast. Within this wall (where each small *living* reef represents a battlement) is

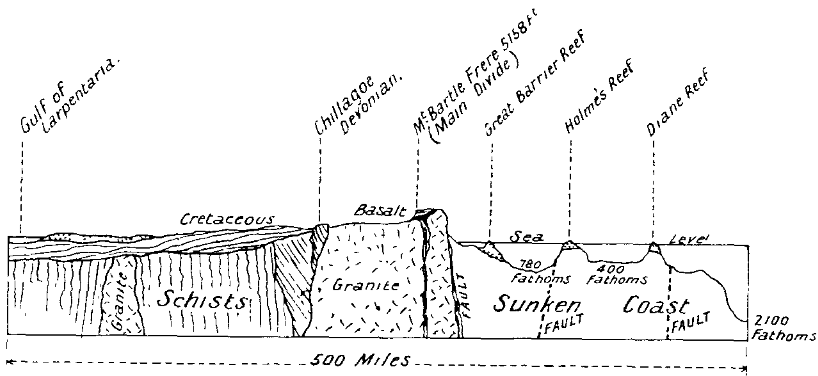

FIG. 4.—Section across North Queensland (after Prof. David).

an inland sea averaging about 20 fathoms in depth. In these clear tropical waters are found the pearl-shell, turtle, and beche-de-mer, whose collection constitutes industries which centre at Cooktown and Thursday Island.

Settlement has not radiated from the capital of the State to such an extent in Queensland as elsewhere in Australia. Mining led to the growth of coast towns such as Cooktown, Cairns, Townsville, and others in the far north. Short railways were pushed inland to reach the mines. The isolated sheep and cattle stations also made use of the railways, and the pastoral holdings soon increased in number and value.

Towns and Industries.—There are four important railways crossing the Cordillera in Queensland. The most northern line from Cooktown leads inland to the mining fields near Laura. At Cairns the Barron River is cutting back a 600-feet gorge (into the edge of the fault scarp) which heads in the famous Barron Falls. Up this gorge winds the railway to the Chillagoe mines. The country has been found suitable for dairying, and now the railway is prolonged a hundred miles south-west to Charleston, so that it reaches the lower country west of the highlands.

Inland from Townsville runs one of the chief Queensland railways. This makes no use of the main river valley, that of the Burdekin, for the latter traverses the coast range through an impassable gorge. The railway originally extended only to Charters Towers near the Upper Burdekin, but now reaches far inland almost to South Australia, and will perhaps link up with the projected transcontinental line to Port Darwin. Near Booroman it crosses the Main Divide, which is here barely noticeable though to the north basalt ranges form a striking feature.

Further south along the coast is the port of Mackay, one of the most important sugar centres in Australia. It is connected by excellent steamer service to the other ports, but no railway yet links it to the capital. Wedged in by the granite range to the west, it has a network of local railways bringing cane to the central mills.

Of far greater importance, however, is the area included in the basin of the Fitzroy River, which exhibits the same features of ancient stream capture from the western system as does the Burdekin.

Far inland along the Tropic of Capricorn runs the railway from Rockhampton. It crosses the low divide at Jericho, and at present ends at Longreach. A rich pastoral and mining region is served by this line. To the south-west of Rockhampton lies Mount Morgan (25 miles), one of the best-known gold and copper mines; and Dawson, destined perhaps to be one of the chief coal-fields of the southern hemisphere, is also in the Fitzroy valley.

The same general features as those described for the northern part of Queensland characterise its southern portion. Sugar ports, such as Bundaberg and Maryborough, also serve as outlets to mining districts such as Gympie and Kilkivan. A very flourishing area of basalt country known as the Darling Downs is devoted chiefly to agriculture. The railway from its chief town (Toowoomba) descends the scarp of the Downs and reaches the coal basin of Ipswich; thence proceeding down the valley of the Brisbane River it reaches the capital of the State.

Although a coast railway is projected from Brisbane for 960 miles north to Cairns, yet at present only the section from Brisbane to Rockhampton is completed. This delay in linking to the capital is directly due to the presence of the granite ranges. Though now forming the coastline and preventing easy communication, these were in Tertiary times flanked on the east by a broad area of piedmont, which has now sunk beneath the Pacific. With this subsidence is correlated the growth of the coral reefs of the Great Barrier.

(b) The South-eastern Highlands in New South Wales.

General Physiography.—The structure of the highland region of the Mother State differs somewhat from that of Queensland, and considerably more is known of its physiography, which may be summarized as follows:—

There are three massifs of Palæozoic rocks buttressed by granite bosses. In the north is the New England tableland (3,000 feet to 5,000 feet), extending from Queensland to the Liverpool Ranges. Then there is a well-marked broad gap where the divide sinks to 2,000 feet from heights of 4,000 feet north and south. To this gap—due to the erosion of the tributaries of the Hunter in the soft coal measures—the name of the Hunter (or Cassilis) geocol has been given.*

In the centre of the highland belt is another plateau of about 3,000–4,000 feet elevation extending from the volcanics of the Canobolas (near Orange) to the great Blue Mountain scarp behind Sydney. It is bounded on the south by another broad gap—the Lake George geocol.

* Geocol is a word coined to express a col or gap on so large a scale that it influences rainfall, vegetation, and communications.

In the south is a pair of massifs exceeding 7,000 feet in the south-west separated from each other by the long narrow valley of the middle Murrumbidgee.

But the most striking feature is the presence of the great coal-measure basin or geosyncline which centres at Sydney and extends north for 200 miles to the Liverpool Ranges, and south for 100 miles to Moruya. Two great beds of payable coal (the Newcastle and Greta seams) extend under a large portion of this area, like two black saucers whose eastern rim has been truncated by the faulted sea coast.

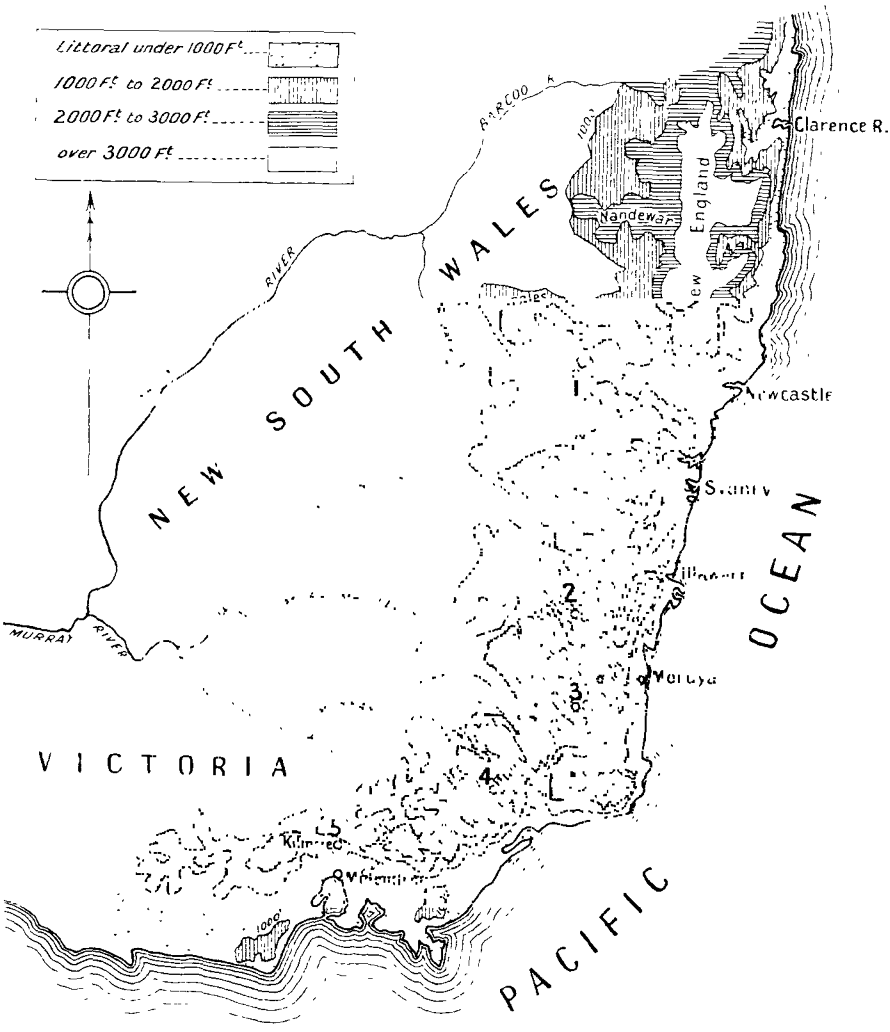

FIG. 5.—Map of the main orographical features in South-Eastern Australia, showing the five geocols or breaks in the Cordillera at (1) Cassilis, (2) Lake George, (3) Cooma, (4) Omeo, and (5) Kilmore. The white western area is less than 1,000 ft. in elevation.

The effect of this geosyncline on the topography is not, however, so marked as might have been expected. Not only the coal-measures (of

Permo-Carboniferous age), but also earlier and later deposits have participated in the far-reaching coastal movements of Tertiary times. On the whole, we may describe the Cordillera region here as having a gentle slope

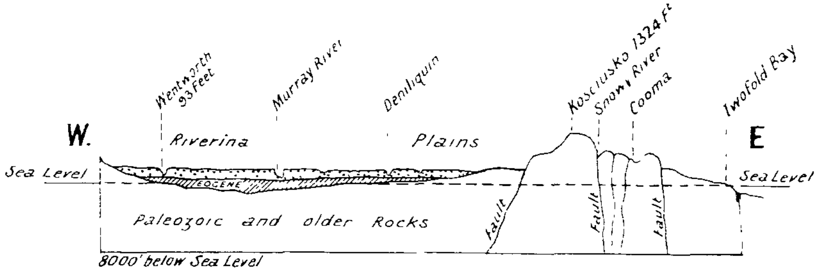

FIG. 6.—Section across the south of New South Wales (after David) showing the horst of Kosciusko and the block-faulted peneplain.

to the west and an abrupt edge on the east, some 2,000 feet high, which has been truncated by coastal subsidences. These, however, occurred so long ago that coastal erosion has gnawed away the sharp faulted edges.

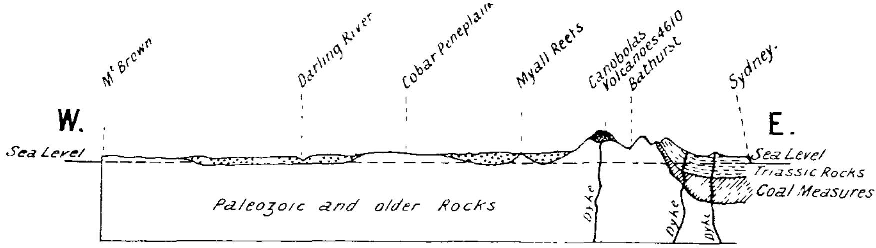

FIG. 7.—Section from the Barrier Range to Sydney (after David) showing the Mt. Brown and Cobar peneplains separated by the alluvials of the Darling River, and the warped peneplain of the Main Divide with the coal basin lying to the east of it.

Moreover, where the rocks are softer—as in the basins of the Clarence and Hunter Rivers, and in the soft marine shales of Illawarra—a comparatively wide coastal plain has resulted from the ordinary processes of erosion.

Towns and Industries.—In the north-east the coastal plain, watered by the Clarence, Richmond, and Tweed, differs somewhat from the remainder of New South Wales. It is characterized by a "soft-wood brush," a relic of a Malay flora preserved here by suitable temperature and rainfall. Here also is grown all the sugar of the Mother State, for it has been found too cold for the canes south of the Clarence Basin. Grafton, Lismore, and Murwillumbah are devoted to sugar growing and dairying, and are linked together by an isolated railway system of their own.

The New England plateau is a resistant mass of Palæozoic rocks (uplifted in late Tertiary times) whose eastern boundary appears to be determined largely by a series of grand fault-planes. The streams flowing to the sea cascade several thousand feet into deep narrow gorges, of which those at the head of the Macleay will undoubtedly be renowned beauty-spots in the near future. Pastoral industries and mining form the chief occupations of the people in New England, and here English fruits thrive well. Armidale is the chief town, while Tenterfield and Glen Innes lie further to the north on the railway which runs along the plateau-like divide.

The Hunter geocol, drained by the Goulburn and Hunter Rivers, is marked by a lower rainfall than any other portion of the State east of the Divide. Accompanying this lack of moisture is a prevalence of some of the western flora (*gidya* trees, etc.), which is unknown elsewhere in the littoral province. The valley is very fertile in its lower portions, and grows great crops of lucerne and maize; dairying is carried on also, but coal mining is the chief industry of the towns around Newcastle, while the upper portion (the Goulburn Valley) is occupied by sheep stations.

The Blue Mountain area is typical of the topography of much of southern New South Wales. In place of steep ranges with broad valleys between, there are here rather broad undulating plateaux dissected by narrow deep gorges and bounded by fault scarps or huge monoclinal folds. The block diagram explains the origin of the wonderful Blue Mountain valleys. The rivers cut down their beds as the monocline rose in their path; in the upper

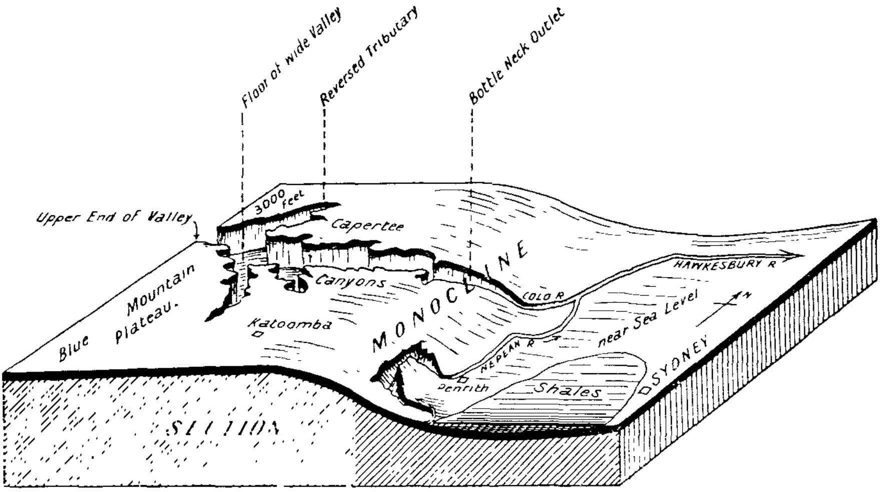

FIG. 8.—Block diagram showing the relation between the resistant Triassic sandstone (black) and the "bottle-neck" valleys of the Blue Mountains. The effect of the monocline on the Nepean Valley is also indicated.

portions the structure of the rocks was weak and as soon as the hard surface-layer (black) was cut away, the soft shales below were readily removed, and so a broad valley resulted. At the monocline slope, however, the river is still sawing its way through the hard sandstone; and so these great valleys contract to very narrow "bottle-necks," where the rivers emerge on the coastal plain. The Nepean Gorge is due to the river keeping its old path in spite of the fold which slowly rose across part of its bed. The Blue Mountain plateau is some 80 miles in diameter, with an elevation of 2,000–4,000 feet. To the north is a barren expanse of Trias sandstone intersected by the Capertee River and its tributaries. To the west it is capped by the ancient volcanic cones of the Canobolas Mountains. On the south-east it is drained by the tributaries of the Hawkesbury River.

The Physiography of the Sydney District.—Sailing along the coast northward to Sydney one sees a long and almost precipitous scarp behind the narrow coastal plain of Illawarra. This scarp, which is about 1,000 feet high, is the truncated edge of a sandstone plateau and is not a ridge in any sense of the

word. North of Bulli the scarp is coincident with the coast, and the inhospitable cliffs immediately south of Sydney are built of this Trias sandstone. Northward the same features are found, until the lower coastline

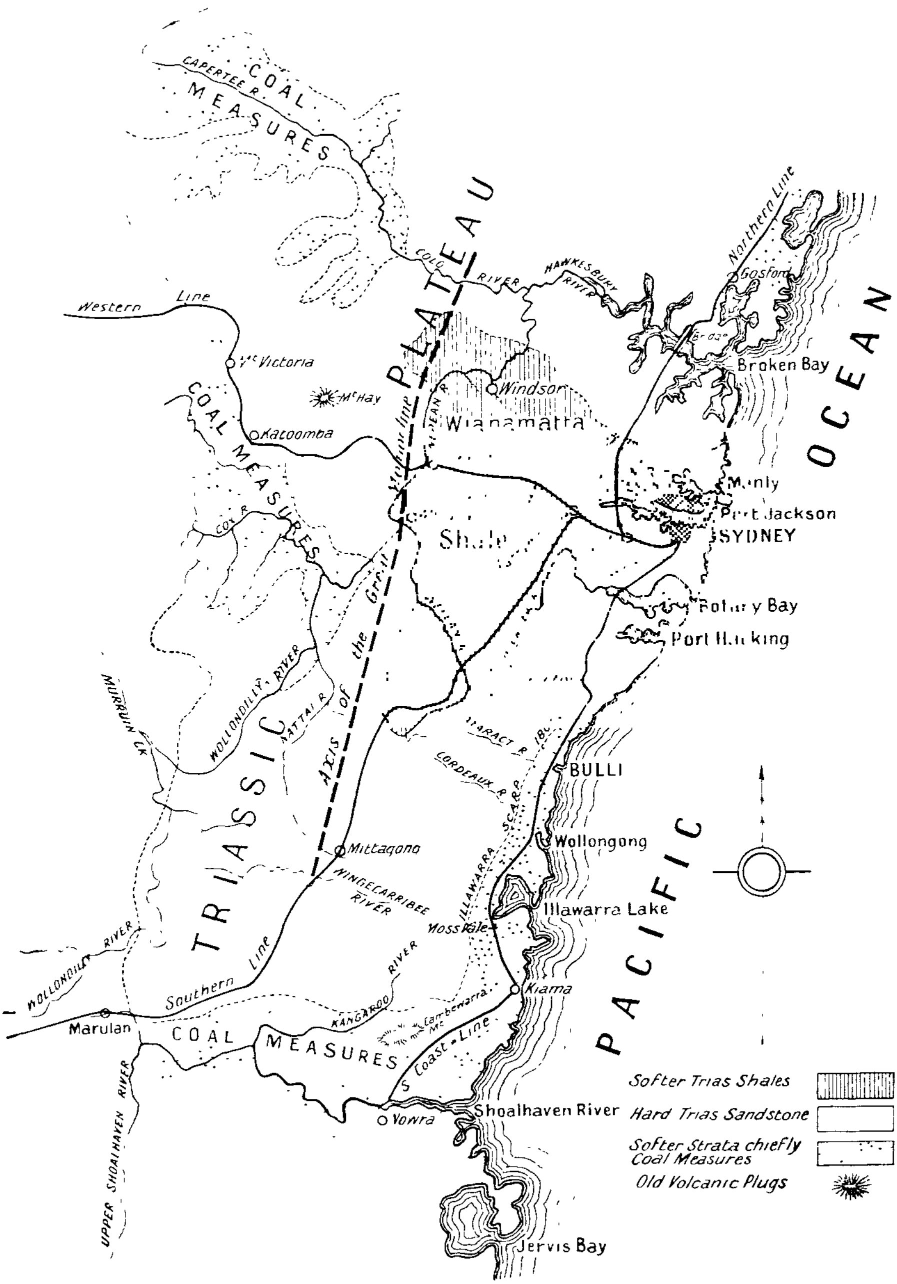

FIG. 9.—The main physiographic features in the vicinity of Sydney.

beyond Broken Bay is reached. This also is due to a change in the geological formation, softer shales or coal-measures outcropping all along the coast north of this point.

The most striking features, however, are the beautiful drowned river valleys. Sydney Harbor is the type example, and is renowned all over the world. It is especially valuable as a harbor, because no large river drains into it; hence there is no silting. Quite probably the Cox River once drained into the harbor, but owing to the drastic changes in the drainage in late Tertiary times, a river (the Nepean) running at the foot of the monocline (Fig. 9) has captured all the streams. Before dealing further with the monocline let us glance at the rivers near Sydney.

Notice the manner in which the four rivers south of Sydney flow directly away from the coast. These are the Cataract, Cordeaux, Wingeecarribee, and Kangaroo Rivers. They rise on the coast and flow due west in ancient broad valleys for many miles. This implies a long-continued period of normal erosion, and obviously when these valleys were formed there could not have been coastal cliffs a thousand feet high immediately at their origin as at present. We are led to believe therefore that not far back in geological time there was an extensive area to the east of this divide—perhaps 100 or 200 miles wide—which has lately subsided beneath the waves.

There is not a single main river in the Sydney region which behaves normally, *i.e.*, flows down the chief line of slope directly to the sea. The Upper Colo (or Capertee) is built up largely of streams which are directed upstream to the west. Some tributaries of the Cox River show the same feature.

In addition to this huge subsidence there is an even more striking feature in the shape of the Blue Mountain monocline (Fig. 8) up which the western railway climbs between Penrith and Katoomba. This is a simple fold in the crust whereby the western region has been raised 2.000 or 3,000 feet above the area lying to the east of the fold. It can be traced 60 or 70 miles in a north and south direction. It has dammed rivers at Picton and Mountain Lagoon. At Mulgoa, Mittagong and other places it has given rise to rivers which flow *from* flat plains into mountain regions in a most amazing fashion. We have in fact a system of western drainage upset by a buckling of the crust, so that most of it is captured by the subsequent north-south Nepean River; but other portions placidly pursue their old courses—cutting into the land as it rose athwart their beds, and still heading west in a vain endeavour to reach the vanished central Australian sea.

Towns and Industries.—Around Sydney the coastal plain is about 40 miles broad, reaching to the River Nepean below the Blue Mountain monocline (Fig. 8). This plain is the centre of an old Triassic lake; for a great portion of it consists of bluish shales (Fig. 9), raised but a hundred feet above sea-level. These shales furnish a clay soil much more suitable for agriculture than are the barren Trias sandstones underlying and surrounding them. The orange and apricot orchards to the west of Sydney occur on this type of soil. Northwards the railway to Newcastle passes over barren sandstone, of little use for aught but as residential sites, until the more fertile coal-measures are reached near Gosford. To the west runs the western railway, passing through orchard country until the Nepean River is reached. Here the flood-silts grow great crops of maize, lucerne, and pumpkins, etc. Then the railway climbs 3,000 feet up the monoclinal fold to the tourist centres

of Katoomba and Mount Victoria. These are built on the same barren sandstone on the flat uplands between the deep valleys of the dissected plateau. Later it crosses the divide beyond the manufacturing town of Lithgow, and reaches the pastoral and mining region between Bathurst and Orange. These are situated on much older Silurian slates, which though not very fertile, are superior to the Trias soils. Only occasionally on this sandstone plateau where Tertiary volcanoes have enriched the soil (as at Mount Irvine and Mount Wilson, near Mount Victoria) are there areas suitable for close farming

The third railway radiating from Sydney runs to the south-west. It passes through the manufacturing centres of Clyde and Granville, and gradually climbs up the valley of the Nepean until Mittagong is reached. From this point it runs at a fairly constant level through poor agricultural country (except where enriched by basalt flows, as near Moss Vale) until the gap south of the Blue Mountain massif is reached near the town of Goulburn. To the west of the line lies a maze of rugged gorges carved out of the sandstone plateau and containing few settlements except those at Yerranderie, where silver is mined, and Wombeyan, where the limestone caves attract many visitors.

Finally, the South Coast railway runs due south over the deep valley of Georges River, and having passed the steep coast characteristic of the Trias sandstone, it descends to the Illawarra coastal plain which is cut in the softer coal measures. Here is a well-watered and fertile dairy country, rich also in easily-worked coal mines. Wollongong and Kiama are two important towns on small harbors formed by more resistant strata. Some 5 or 10 miles back from the coast is the 1,000-ft. scarp of the Triassic sandstone plateau.

The western (plateau) portion of the area we are now considering consists of a land surface exhibiting mature to senile features for the most part. It is a mining and sheep-raising country, the chief towns being Bathurst, Orange, Mudgee, Blayney, Molong, and Crookwell.

South of this area is the Lake George geocol, where the southern railway crosses the divide and commences its descent of the western slopes to the Murray River. The Main Divide hereabouts is somewhat indefinite. Some cartographers put it west of Lake George, others east of the same (through Tarago), while strictly a neighbouring region known as Duck Flat constitutes the Great Dividing Range! A late Tertiary fault with a drop of 400 feet on the east has here blocked the head-waters of the Yass River, and has given rise to Lake George, the largest freshwater lake in Australia

The Yass River joins the main Murrumbidgee River a little above Burrinjuck. Here the latter river—as a consequence of the Tertiary uplift—is flowing down a 1,500-ft. gorge cut in Palaeozoic slates and granites. Advantage of this has been taken to build a gigantic concrete dam 200 feet high which will hold the waters back for 40 miles. The water is to be taken some 200 miles west down the river bed and used to irrigate the western plains near Narrandera.

The land rises to the south of Lake George into two great massifs culminating in Tindery (5,000 feet) and Kosciusko (7,300 feet), and between them is the long rift valley of the Murrumbidgee.

The northern portion of this valley with the adjacent highlands constitutes the Federal Capital Territory. This is an area of 900 square miles relinquished by New South Wales to the Commonwealth for the purpose of building a southern "Washington." The site of the city itself (9 square miles) is at Canberra on the Molonglo River, about 36 miles south from Yass (on the main southern railway) and 8 miles west from Queanbeyan (on the Cooma railway). It is situated on a broad plain, which is overlooked by three isolated hills or monadnocks 800 feet high, and is traversed by the meandering shallow waters of the Molonglo River. The latter is to be dammed to form a lake 4 miles long.

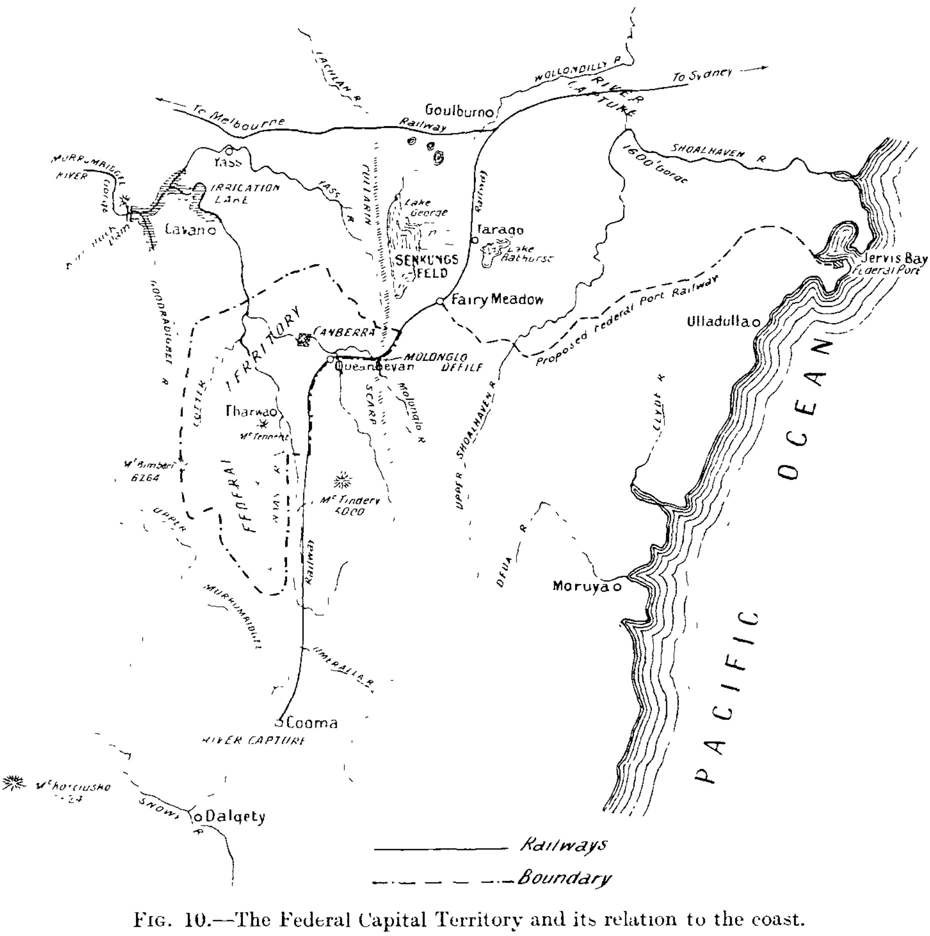

FIG. 10.—The Federal Capital Territory and its relation to the coast.

To the south-west of the Territory is a great granite horst,* rising at Bimberi Mountain to 6,000 feet, and connected directly with Mount Kosciusko. This is traversed by deep north-south valleys, one of which, the Cotter Valley, is to contain the water supply of the city. The Territory is occupied by about twenty sheep stations together with one or two cattle

* A horst is a residual block of the earth's crust which has not participated in the wide-spread depression of the neighbouring country.

stations in the rugged southern region. The city site is at an elevation of 1,900 feet above sea-level, and has an average rainfall of about 20 inches Some 30 miles to the south the rainfall has, however, increased to 50 inches, so that a good water supply is assured from the upper Cotter.

The two mountain masses we have now to consider are undoubtedly relics of a uniform topography which has been cut in two by a system of rifts and senkungsfelder* (Fig. 5). The main depression thus formed is now occupied by the upper Murrumbidgee River and the middle Snowy River. There is a low gap near Cooma connecting the two valleys which has every appearance of having originally been the outlet of the upper Murrumbidgee. The eastern Tindery horst has its flanks washed by the Pacific Ocean. There is practically no coastal plain hereabouts, but flourishing dairying and mining settlements have been established at the numerous river mouths. Milton, Ulladulla, Moruya, Eden, and Bega are towns of this character. No railways have yet been built, and the coach road climbs some 2,000 feet to reach the horst and senkungsfeld country to the west. The latter in its southern half is called the Monaro, and is chiefly used for cattle-rearing. There are many sheep-stations, however, in the fault depressions between the horsts. Some mining is carried on, chiefly at Kiandra and Araluen. The Monaro culminates in the summit of Australia—Mount Kosciusko (7,340 feet)—in the south-west. This is easily reached by a good motor road from Cooma, but on the west its slopes descend almost precipitously to the waters of the Upper Murray.

(c) The Victorian Cordillera and its Coast Plains.

Nowhere is the artificial nature of our State boundaries better shown than in the south-eastern corner of the continent. The massif of Kosciusko continues uninterruptedly across the border into Victoria, forming a large high-level plateau whose summit is second only to Kosciusko (Fig. 5). A favourite tourist resort is Mount Buffalo, another flat-topped granite horst between tributaries of the Ovens. Westward of the Omeo gap the plateaux are more dissected, and indeed become real ridges which dwindle to a level of about 1,200 feet at Kilmore Junction. Beyond this, to the west, there are more or less isolated mountain elements, such as the Pyrenees a series of granite bosses, and the north-south sandstone ridges of the Grampians.

A mountain "range" of greater uniformity than the great Divide would seem to have once run along the present Victorian coast in the form of the uplifted Jurassic sediments of the Wannon Hills, Cape Otway Ranges, and South Gippsland Hills. Between these and the main Divide lies the Great Valley of Victoria.

Towns and Industries.—The rugged east-central portion of Victoria is practically uninhabited. There are a few small mining townships (Omeo. Bright, etc.), and one or two tourist resorts such as Buffalo ; but, for the rest, it is more profitable to settle in the coastal plains to the south, or in the lower valleys of the Murray tributaries to the north.

The Gippsland Lakes—really lagoons formed by dunes drifting across the mouths of the rivers—are favourite resorts of tourists and fishermen

* A senkungsfeld is an area depressed below the general level by trough-faulting.

Bairnsdale, on the Mitchell River, is an important town and railway terminus; Sale, nearer Melbourne, at the western end of the Lake District, is the chief town in Gippsland. Farming, dairying, and pastoral occupations support the people, while the foothills (as at Walhalla) have yielded a considerable quantity of gold.

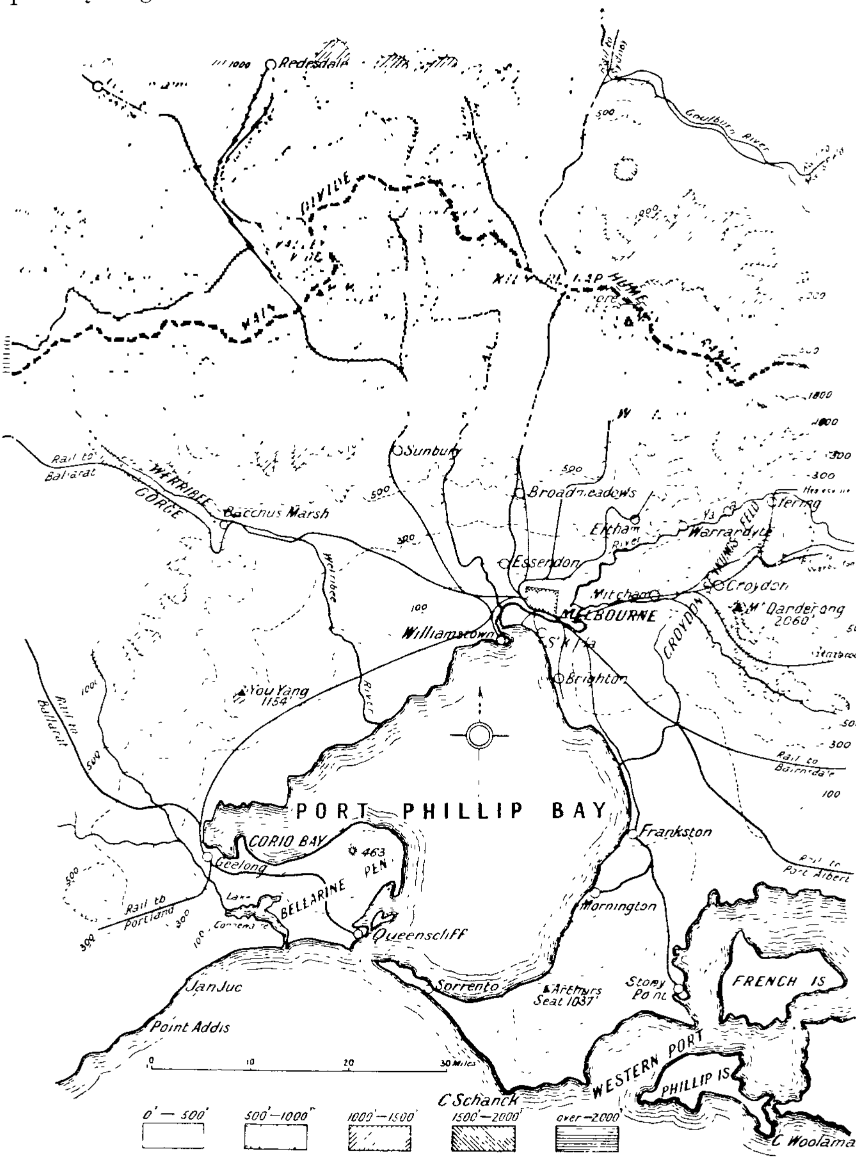

FIG. 11.—The topography of Melbourne and its environs.

The high rainfall (45 inches) of south-west Gippsland is accountable for the growth of the giant eucalypts. These are the largest hardwood trees in the world; some over 320 feet in height have been measured.

North of the mountains are small townships which in the east are chiefly devoted to mining (Beechworth and Yackandandah). Wangaratta, Benalla,

and Seymour, on the Inter-State railway, are flourishing towns devoted to farming and pastoral industries generally. The rough country to the south of Benalla was once the haunt of numerous bushrangers, of whom Kelly was perhaps the most notorious.

When the Kilmore geocol is passed in our traverse to the west, the character of the country changes considerably. A network of railways crosses without difficulty the so-called Dividing *Range*, and to the north-west sends out the six tentacles which have helped so greatly in developing the Wimmera and Mallee plains. Ballarat, Bendigo, Castlemaine, Ararat, Stawell all owe their origin to gold mining, and their present prosperity in no small degree to the less fluctuating profits of agriculture and sheep-farming.

Melbourne has grown up around the mouth of the Yarra, and has spread southward along the flat tea-tree covered shores of Port Phillip for 15 miles or so. Williamstown and the large town of Geelong have been settled in suitable sheltered spots on the western shores of the Bay. The climate and soils of the surrounding districts are eminently suited to farming and fruit growing

Melbourne is situated in the centre of a saucer-like plain of about 35 miles radius (Fig. 11). The rim is fairly complete to the north, but is interrupted by broad gaps to the south. The southern part of this plain has been drowned by the sea, and constitutes Port Phillip. The most prominent elevations near Melbourne are of volcanic origin. Thus Mount Macedon (3.324 feet) consists of dacites and trachytes, and is a conspicuous peak on the Divide; but just behind this the Divide separating the Campaspe (which joins the Murray River) and Saltwater Rivers is 1,200 feet lower and almost indistinguishable.

On the north the " notch in the rim " at the Kilmore Gap is only 1.145 feet high, so that Melbourne is peculiarly well suited to collect the products of the Upper Murray basin. The long narrow Hume Range culminating in Mount Disappointment bounds it on the north-east. South of this is the very interesting valley of the Yarra. Extensive trough-faulting has produced the Croydon senkungsfeld; however, the Yarra has not taken advantage of this outlet, but has continued on its old course, cutting a deep gorge through the Mitcham-Eltham plateau as the latter rose in its path.

Another gap, occupied by the Koo-wee-rup Swamp and the tea-tree flats behind Carrum, occurs between the Dandenong volcanics (2,060 feet) and Arthur's Seat. A similar pair of elevations—Mount Bellarine and the You Yangs—define the circular plain on the south-west.

Finally, in the west, is the low scarp of the Ballarat Plateau. This is very prominent near Bacchus Marsh, where a striking loop on the railway is due to this feature. Cutting through this scarp in a picturesque gorge is the Werribee River, famous for its sections of Permian glacial beds.

West of Port Phillip is a basaltic lowland area known as the Western District. It is studded with ancient craters, of which that at Tower Hill may well have been the last active volcano in Australia. The basaltic plains extend from Melbourne to the Glenelg River, a distance of about 150 miles, and are about 50 miles broad. With its ample rainfall and fertile volcanic soil, the Western District is one of the richest pastoral and agricultural areas in Australia. Its chief towns are Hamilton, Terang, Camperdown, and Colac.

In this region are several centres of closer settlement, served by the ports of Warrnambool and Portland. Railways connect these ports to Melbourne, but it is hoped that the capital city (which is twelve times larger than any other Victorian town) will be saved from further congestion by their greater independence.

(d) Tasmania.

Separated from the mainland by the late subsidence of Bass Straits, Tasmania forms a unit which has not foundered like much of Tertiary Australia. Two important trend lines associated with granite bosses running down each side of the island would seem to have buttressed and preserved the central sediments. The central plateau consists of coal-measures capped largely by basic lavas. These huge mesa-like massifs are known as "Tiers." Though they may have been isolated by block faults yet the protection from erosion by the hard cap of lava may account for their characteristic structure. Cradle Mount (5,069 feet), at the north-west of the plateau, presents to the sea a huge scarp, which is probably due to an extensive N.W.-S.E. fault plane. Large lakes, drained by rivers which have cut deep gorges in the edges of the Tiers, occur on the plateau.

The south-west is uninhabited. It consists of series of strike ranges running north-west and south-east, which have been dissected into deep valleys by the Gordon and other rivers. A rainfall of 50–100 inches occurs in the west, and a dense scrub of interlocking trees and creepers almost wholly prohibits communication at present. However, in the north-west the extremely rich mining fields have led to the country being opened up by a narrow-gauge railway in spite of great natural obstacles.

Towns and Industries.—With the exception of the mining region mentioned above, almost all settlement is confined to the eastern lowlands between the central plateau and the sea. Along the north coast, east of Table Cape, is a flourishing agricultural and pastoral region, the chief towns, Burnie, Devonport, and Latrobe, lying on the estuaries of the chief rivers. Wheat, dairying, and cattle are more important in the north than wool-growing, which centres rather in the Derwent and Macquarie Valleys.

The chief railway connects Hobart (the capital) with Launceston (the second town) on the Tamar estuary. It passes through a country whose climate has often been compared to that of England, though its latitude is rather that of the Riviera.

The eastern tributaries of the Tamar rise in the Ben Lomond massif—which reaches 5,000 feet. To the south-east of this highland are the coal mines of Fingal, situated on the South Esk River in one of the eastern valleys which are noted for their sudden floods.

The environs of Hobart are devoted to the growth of English fruits, especially apples, but wheat and dairying are also important industries. New Norfolk, Hamilton, Bothwell, Sorrel, and Oatlands are the chief towns in the Derwent basin; while Launceston, Deloraine, Longford, Westbury, and Campbelltown are the chief centres of settlement on the tributaries of the Tamar.

3.—The Lowland Belt of Australia.

Between the Eastern Cordillera and the Western Tableland lie the Central Lowlands. This area is conveniently divided into the Murray-Darling Lowland in the south, and the Artesian Lowlands in the centre and north.

In Permian times there was a long and rather narrow depression extending from Cooktown (Queensland) to Cape Howe (New South Wales), while the central portion of Tasmania was also occupied by the Permian Sea. In these seas were deposited sediments conformable with our chief coal-measures. Since the coal seams in the latter are of freshwater origin, the sea was occasionally shut off from the ocean and presumably restricted in area.

In Triassic times the region further to the west sank, and the main axis of submergence seems to have moved west also. Somewhat later, in Cretaceous times, a further depression took place, still to the west. The deposits now laid down constitute the greater part of the lowlands under consideration. There we see the present river systems initiated—for most

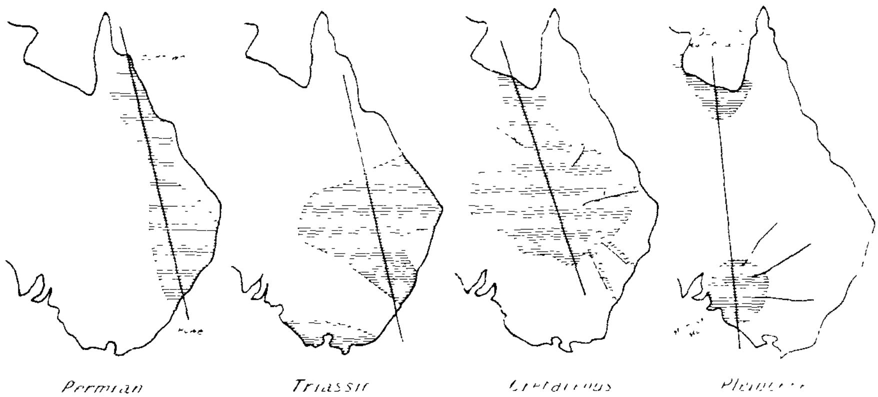

FIG. 12.—Main drainage basins in post-Palæozoic periods, showing the gradual movement of the trough axes to the west.

of the inland rivers, *e.g.*, Upper Lachlan, Castlereagh, Macquarie, Condamine, and Barcoo, are heading for this ancient sea. An elevation *en masse* has turned the Cretaceous sea into dry land, and also raised the cordillera higher. In later Tertiary times the gulfs which were relics of the Cretaceous sea (at Murray mouth and south of Carpentaria) were also elevated, and Australia arrived at its present shape.

In the southern portion the Mesozoic marine sediments (here largely Triassic) have been covered by an extensive deposit of river silts and estuarine gravels. In the far south occur the upraised Tertiary marine beds which were deposited in the Murray gulf at a time when the tributaries of the Murray River entered the sea by separate mouths.

4.—The Murray-Darling Lowlands.

The southern portion constitutes the Murray-Darling Lowlands.

This is an approximately square area of some 400 miles wide, which lies chiefly in New South Wales. The boundaries are fairly well defined on the south by the portion of the cordillera forming the Victorian highlands. On the west it is flanked by the inliers of very ancient slates and quartzites (of Cambrian age or earlier) which constitute the Flinders and Barrier Ranges. On the east it rises gradually to the three tablelands already considered. The foothills (below 2,000 feet) may be classed as lowlands.

On the north the boundary between this division and the Great Artesian Basin is not apparent from surface features. It has been mapped from borings, and runs along the rivers Bogan and Darling to Bourke, and thence in a general westerly direction until the Cambrian highlands are met with beyond White Cliffs.

(a) Cobar-Wagga Peneplain.

It is impossible to define sharply the boundary to the east. If we accept the 2,000-ft. contour as a natural limit of the dry lowlands (which view is supported to some extent by the isohyetals and by the distribution of the plains vegetation), then considerable areas of folded Palæozoic rocks are included in these lowlands. They may be grouped in one division, which has

FIG. 13.—The Murray-Darling Lowlands and their subdivisions.—1. Cobar-Wagga Peneplain; 2. Western Plains and the Riverina; 3. Ancient Murray Estuary.

been named the Cobar-Wagga Peneplain.* Unlike the Eastern Cordillera it has not participated to any great extent in the Tertiary uplift, and so it really very closely represents early Tertiary Australia. It is rich in minerals, especially gold and copper, and elsewhere has been named the "Gold-Copper Slope" for this reason.

Towns and Industries.—The area is of an hour-glass pattern, the valley of the Lachlan almost separating the two inliers of ancient mineralized rock

* A peneplain is an old land surface planed down by rivers and other erosive action nearly to sea level It may afterwards be elevated, but retains the same features, of course.

In the Cobar moiety mining and sheep-grazing are universal, the chief towns on this "Palæozoic island" being Cobar, Nymagee, Nyngan, and Narromine.

In the southern and eastern portion of this peneplain the rainfall is greater (15–25 inches), and an important portion of the wheat belt is included within its area. Wagga, Young, and Albury, and, in the north, Parkes and Forbes, are wheat centres, and with dry farming and suitable wheat the belt is spreading to the west. Wyalong, Forbes, Parkes, Adelong, and Young are centres of gold and copper fields, and since sheep also graze here in large numbers it is seen that these southern foothills in New South Wales are usually rich in pastoral, mining, and agricultural resources.

(b) The Western Plains and the Riverina.

These plains lie along the course of the Darling (south of Bourke), and penetrate considerable distances into the Cobar-Wagga Peneplain. Their greatest breadth (200 miles) is in the Riverina—a name given to the Mesopotamia of the Lower Lachlan, Murrumbidgee, and Murray rivers. For several hundred miles no hill is met with; indeed, no rock outcrop breaks the monotony of the plains.

The great rivers for the most part flow in rather deep gullies through these plains. In times of drought, the Darling and Lachlan degenerate to a string of waterholes, but the Murrumbidgee rarely ceases to flow and the Murray never. During the floods which occasionally occur, the rivers spread for miles over the plains and re-occupy ancient channels. Later these are left as serpentine "billabongs," and large lakes may originate thus. There are said to be 70 of these lakes along the Lower Darling.

More or less permanent distributaries are also common on the Lower Darling and Murrumbidgee, and are locally known as anabranches.

Towns and Industries.—The plains country is devoted to the merino sheep. The rainfall is too low for wheat, except in the eastern Riverina, where the precipitation rises to 20 inches. Large holdings of land are necessary in the western plains, and single stations may have as many as 100,000 sheep. In the west there are only one or two towns of any importance, which distribute stores to the sheep stations and receive wool for transport *viâ* rail or steamer to Melbourne or Sydney. Among those further east may be mentioned Deniliquin, Hay, Moulamein, Condobolin, Jerilderie, and Narrandera.

An area of great economic interest is located on the Lower Murrumbidgee near Narrandera. Two hundred miles up the river is the Burrinjuck Dam, below the junction of the main stream with the Yass and Goodradigbee rivers. The retaining wall is to be 240 feet high, and will dam back the water for 40 miles up the main stream, with important additions in the Yass and Goodradigbee valleys. From the dam the conserved water flows at first *viâ* the river channel, and later by an artificial cut to the Yanco irrigation area. It is expected that about 200,000 acres of first class land and 360,000 acres of second class land near Yanco can be subdivided for intense culture.

The special feature of this region is, however, the important river system consisting of the River Murray and its tributaries. With its main tributary, the Darling, no less than 2,000 miles are navigable in favorable seasons, but internal navigation is decreasing in importance as the railways are extended

With a high river the Murray is navigable practically to Albury, but there is very little traffic beyond Echuca (which is 666 miles from the South Australian Border). On the Darling steamers trade as far as Walgett, a distance of 1,180 miles from Wentworth. The Murray is navigable for about seven months (July to January inclusive) in the year: the Darling may be blocked for several years in a dry series of seasons.

(c) The Ancient Murray Estuary.

An approximately circular area in the south of the Australian Lowlands occupies an old bay or estuary into which the Darling, Murrumbidgee, and Murray probably entered by separate mouths. It extends from Menindie, on the Darling, to Glenelg River (western Victoria), and is about 300 miles broad, its limits being Swan Hill (on the Murray) to the east, and the Mount Lofty Ranges (South Australia) to the west. In this region the rocks consist of marine sediments of late Tertiary age, which not long ago formed the floor of portion of the Southern Ocean. The rainfall is rather low (10–20 inches), the country being sheltered by hills from rain-bearing winds; but large areas which were formerly deemed worthless are progressing rapidly since it has been discovered that wheat can be profitably grown here. The natural vegetation, especially in the southern portion, consists of a low shrub-like eucalypt called the "mallee," which forms very thick copse-like masses. This is being cleared to make way for the wheat. The Lower Murray passes through the middle of this tract, in which it receives no tributaries except in time of flood.

In the south-east the rainfall increases, and the Wimmera District is supplied by the head waters of several streams which rarely reach the Murray. Here there are extensive irrigation and water supply works as at Glenorchy, Dooen, and Boort. Some of these enable large crops to be grown, others supply water for stock in the drier periods of the year.

The irrigation centres of Renmark and Mildura on the Murray (near the Darling confluence) are of great interest. Here large fruit crops are obtained in a region with only a 10-in. rainfall, by water pumped from the Murray. The drainage of the whole Murray basin enters the sea by an insignificant outlet so shallow that none but the smallest steamers can cross its bar.

The portion of this elevated Tertiary estuary which has been settled most successfully lies in the south-eastern corner of South Australia. With a good rainfall of 30 inches this corner of the State is noted for its crops and fruit, and it enjoys the most favorable climate of any part of the State of South Australia. This is largely due to the fact that it extends sufficiently far south to be influenced by the dominant rain-bearing westerly winds for a large part of the year.

There is here, however, a sub-artesian water supply which is really deleterious. A large area between the Mount Gambier Railway and the coast was originally a sour swamp land, being flooded by the outflow from the more elevated porous beds to the north and east. The crater lakes of Mount Gambier owe their water supply to this artesian flow. A very large drainage scheme now in progress has already cost £314,000 and will cost as much again. This will improve 2,000,000 acres of agricultural land.

5.—The Great Artesian Basin.

This region constitutes the northern portion of the Central Lowland belt of Australia. It includes about 576,000 square miles, comprising more than half of Queensland and important slices of territory in New South Wales and South Australia.

During Mesozoic times a large gulf extended from the Gulf of Carpentaria to Lake Eyre. This covered much the same ground as the Artesian Basin, to which, indeed, it gave rise. In this basin were deposited thick beds of

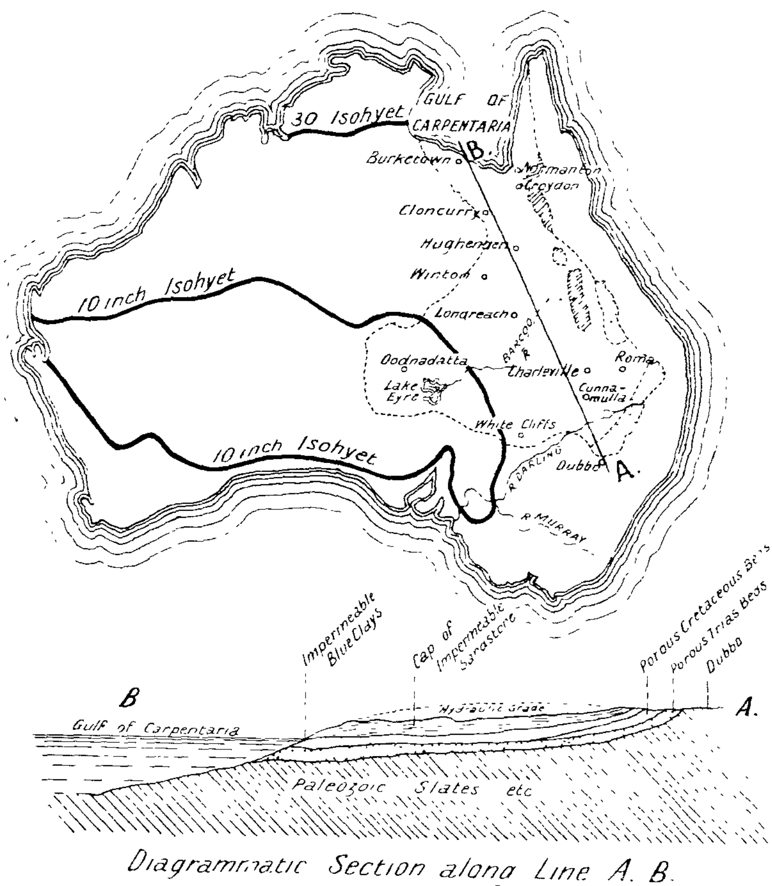

FIG. 14.—The Great Artesian Basin.

sand, which ultimately became a permeable sandstone, and over these were laid down strata of an impermeable nature (blue clays, shales, etc.). Later, earth movements elevated this area, and the underlying peripheral porous sandstones were exposed by erosion.

Rain falling on the upturned porous beds (which are perhaps Triassic in New South Wales, and Cretaceous in Queensland) is rapidly absorbed, and flows underground towards the lower portion of the basin, which probably occurs in the north. There is probably an outlet for this underground flow

into the Gulf of Carpentaria. Many mound springs to the west of Lake Eyre—along the railway line—also represent a natural outlet to this basin. In New South Wales there are nearly a hundred Government bores and about 250 private bores. At Dolgelly (near Moree) a bore was sunk 4,806 feet and gave 682,000 gallons per day. In Queensland there are about 600 flowing bores and 168 sub-artesian where the water does not reach the surface without pumping.

The Artesian Region may be divided into two parts, which may be termed the Lake Eyre Division (in the west) and the Eastern Division (which comprises western Queensland). The dividing line is somewhat arbitrary, but is not far from the 10-in. isohyet. Thus the western is practically desert country, and the eastern is a very important mining and pastoral region.

(a) The Eastern or Pastoral Artesian Region.

This belt lies to the west of the cordillera and gradually changes from the uplands of the Great Divide, through rolling downs to the monotonous levels of the region around Lake Eyre. It extends about 1,200 miles from the Gulf of Carpentaria to Dubbo, on the Macquarie River (New South Wales), and is about 300 miles wide.

The northern portion around the gulf consists of a low-lying country—probably the elevated bed of the gulf adjacent—with a rainfall of 20 to 30 inches. It is watered by numerous rivers. Normanton, the chief town, is partly supplied with water by an artesian bore. Behind the mangrove swamps of the northern margin is an important cattle-grazing district. The chief industries are, however, connected with mining, much gold being obtained at Croydon and copper at Cloncurry. These ore-deposits occur in "islands" of older rock, projecting through the artesian water-bearing strata.

To the south of the gulf country the land rises considerably, and a strip about a thousand feet above the sea extends south to the headwaters of the Paroo and other northern tributaries of the Murray, whence it gradually slopes down to 500 feet along the southern boundary of the Artesian Basin.

It is important to note that this portion of the Artesian Basin lies almost wholly in the 10 to 20 in. rainfall area, so that except in the extreme south, where some wheat is grown, there is nothing to compete with the pastoral industry. Hughenden, Winton, Barcaldine, Charleville, and Cunnamulla are all centres of sheep and cattle districts, connected by railways to one of the ports, Townsville, Rockhampton, or Brisbane.

(b) The Lake Eyre Basin or Desert Artesian Region.

The remaining division of the Artesian Basin comprises the lowlands drained by the rivers Diamantina, Barcoo, etc. The lowest portion of the area constitutes Lake Eyre. The southern arm of this lake usually contains salt water, while the remainder is a vast salty plain formed from alluvium carried down by the large rivers which now enter it only in flood time. It is situated within the 10-in. isohyet, yet many pastoral areas have been occupied, especially along the beds of the Diamantina and Barcoo.

6.—The South Australian Highlands and the Associated Trough Faults.

This isolated region of elevation extends from Cape Jervis in a north-south line to Hergott Springs, near Lake Eyre. It consists of "numerous local ranges which in places reach an elevation of over 3,000 feet. The ranges are usually separated from each other by undulating or nearly level plains; and as a result of these longitudinal valleys the northern railway has been carried through the hill country, reaching an elevation near Petersburg of over 2,000 feet, without the necessity of cutting a single tunnel."*

The present topography of the highlands is determined chiefly by a series of faults on the western side of the Cambrian highlands. These faults run meridionally and appear to have taken place in almost every geological epoch. Running parallel to the highlands is a subsidence area which Professor Gregory has termed the "Rift Valley of Australia," which constitutes St. Vincent's Gulf and Spencer's Gulf—York Peninsula being a horst between two subsidences. The Rift Valley extends north through Lake Torrens, and has probably contributed to the origin of Lake Eyre. The scarp faces on the west of the Mount Lofty Ranges are not yet in equilibrium, and slips on a large scale along the old fault lines make this corner of Australia perhaps the most active seismological region in the continent. (See Chapter VII., "Geology of the Commonwealth," Fig. 1.)

To the east the ancient Cambrian and Pre-Cambrian rocks diminish in height and gradually merge in a low level peneplain of old rock which is bounded, and in part covered, by the Tertiary sediments of the Murray-Darling lowlands. In these ancient altered and folded rocks occur the chief mineral deposits of South Australia. Among these are the famous Wallaroo and Moonta copper mines, at the head of St. Vincent's Gulf; Burra and Kapunda, once equally important, have not been worked for many years, but just over the border in New South Wales is situated Broken Hill, the largest known ore deposits in Australia. The traffic of Broken Hill passes almost wholly through South Australia, either to Port Pirie, on Spencer's Gulf, or to the capital, Adelaide. The population is over 30,000, and since 1882, when the lode was discovered, silver-lead-zinc ore to the value of £60,000,000 has been won.

The main divide of these highlands lies somewhat to the west, culminating in Mount Lofty (near Adelaide, 2,334 feet), Mount Razorback (near Burra, 2,834 feet), and Mount Brown (near Quorn, 3,100 feet). None of the rivers are of importance, and in the north the water supply is obtained chiefly from wells sunk in the beds of the intermittent rivers. The lakes are all shallow sheets of salt water, and are worthless from an industrial point of view.

The Cambrian Highlands (including the Mount Lofty and Flinders Ranges) lie in the course of strong westerly winds in winter. They have at that season a rainfall which is found to be eminently suited to the needs of the wheat plant; in fact, many districts with only 10 inches per year can grow an excellent hard wheat, because practically the whole of the precipitation takes place from April to October (inclusive).

* *The Geography of South Australia, including the Northern Territory*, by Walter Howchin and J. W. Gregory (1909), p. 82.

The main settlement in South Australia is therefore confined to a triangle included between Streaky Bay (west), Beltana (north), and Morgan (south-west). Mount Gambier and the Pinnaroo wheat area have already been described as likely to become areas of close settlement.

The heaviest rainfall occurs near Adelaide, on the slopes of the Mount Lofty Ranges. On the lower slopes, where there is less moisture, are planted the vineyards whose wines are becoming favorably known all over the world. Clare and Tanunda are two of the most famous cellars, both being to the north-east of Adelaide.

It is to wheat, however, that South Australia chiefly owes her prosperity. The wheat line coincides, for reasons stated, with the 10-in. (winter) isohyet. The three peninsulas, Eyre's, Yorke's, and Mounty Lofty, are included in this area which is one of the most important wheat producing districts in the Commonwealth.

Wool is grown throughout the State wherever the annual rainfall exceeds 9 or 10 inches, including all the Cambrian highlands. But a large area in the north-west, beyond a line joining Eucla to Oodnadatta, is still No Man's Land. However, just as pastoral industries have paid their way in the dry regions of Hergott and Oodnadatta, where railway transport is available in time of need, so we may hope that the new transcontinental railway from Port Augusta to Kalgoorlie will lead to the settlement of the region in question.

7.—The Great Plateau Region.

To the west of the Australian Lowlands, *i.e.*, beyond a line joining the two gulf regions (Spencer and Carpentaria), lies a vast extent of country forming the chief geographic unit in Australia and embracing two-thirds of the continent; it consists of an ancient peneplain composed chiefly of Palæozoic or older rocks which have been planed down to a more or less uniform level. This now stands 1,000 to 1,500 feet above the sea, and for the most part does not seem to have been submerged since middle Palæozoic times. However, fringing this massif all round the west coast, are lowlands of Tertiary age; while there is a fairly continuous hinterland of Mesozoic and late Palæozoic rocks which resemble the larger belt on the east of the continent. This obviously indicates that the margins of the West Australian massif have oscillated above and below sea-level many times in post-Cambrian times.

Only in the south, at the head of the Bight, is there any large area of late rocks; but here there appears to be a Cretaceous basin extending for a radius of 300 miles all round Eucla.

In this region is comprised the whole of Western Australia and most of the Northern Territory and South Australia, except those portions of the latter which have already been described under the heads of the Lake Eyre Basin and the South Australian highlands. It is by no means so important economically as the Central Lowlands, and supports only about 6 per cent. of the Australian population (250,000 out of 4,000,000).

It will be recognised that there are no dominating physical features to assist subdivision of this large area, except it be the Central Highlands in the east—which form one subdivision.

Since this tableland extends through almost 25 degrees of latitude, it is obvious that it is subjected to very different meteorological conditions. Accordingly the most satisfactory primary divisions are—the Southern Temperate Region, the Northern Tropical Region, and the Central Desert with its enclave, the Central Highlands.

(a) The Northern Tropical Region.

The Tropical Region consists of a broad coastal strip from Sharks Bay to the Gulf of Carpentaria. In this region the rainfall occurs in summer, and increases in amount as the equator is approached. It is bounded on the

FIG. 15.—Map showing the three divisions of the Westralian Plateau, and the 10-inch isohyet.

south and east by the Desert Region. Unfortunately there are no rain stations between Nullagine and Barrow Creek, so that the division line (approximately the 10-in. isohyet) is only tentative.

It may be described under the heads:—

(1) Northern Territory Lowlands;
(2) Northern Territory Highlands;
(3) The North-west Coast, comprising the regions around Kimberley, Pilbarra, Sharks Bay, and the Murchison.

(i.) THE NORTHERN TERRITORY LOWLANDS.

The Northern Territory consists of two rather different provinces. The coastal portion is low-lying, rising only to 300 feet at 100 miles from the coast along the railway. This low country is still practically unknown except along the railway. It does not appear to be very good cattle country, and though the rainfall is very heavy in summer the soil is poor in plant food and the vegetation, on the whole, is scanty, except along the rivers. The hinterland, including Arnhem Land to the east, appears to be a dissected peneplain about 1,000 feet above sea-level.

The rivers and creeks of the Northern Territory are in many cases dry gullies during the dry season; but they become considerable streams in the wet season, from December to March. There are notable exceptions to this. For instance, the Edith, Catherine, and Roper are large rivers, all of which flow at a constant rate all through the dry weather. The most important is the Roper, which rises near Bitter Springs—to which place it is proposed to transfer the capital—and flows perennially thence. It is a noble stream 100 yards wide and occasionally 25 feet deep, though crossed by quartzite bars. Some of the reaches on the river are said to be 40 miles long.

The capital is at Darwin, a small township consisting chiefly of Government buildings. From the capital a narrow-gauge railway runs to Pine Creek, 145 miles inland, and will shortly be extended to the Katherine. A British line of steamers maintains a monthly service, and there is a small local trade, a steam-ship running between Port Darwin, Port McArthur, Daly River, Victoria River, and Wyndham (Western Australia).

The population of the Territory in 1911 comprised about 1,700 whites, 1,300 Chinamen, and some 20,000 aboriginals. The following were the chief products in 1910:—pearl-shell, £10,000; tin, £34,308; and gold, £21,632.

(ii.) NORTHERN TERRITORY UPLANDS.

These extend southward from the Roper River, and include the most promising portion of the Territory. Though the rainfall is less, gradually decreasing from 40 inches to 6 inches, yet the climate is more healthy, and the strip of country southward to Tennant's Creek is well adapted to carry cattle. The railway traverses fair pastoral country as far as Pine Creek, though practically unstocked. There are however, many cattle stations on the low eastern plateau known as the Barkly Tableland. These are linked to the more populous regions by a mail route *viâ* Camooweal just within the Queensland borders.

(iii.) THE NORTH-WEST REGION.

This is wholly included in Western Australia, and consists of a strip of country between the desert and the sea about 100 miles wide, extending from the Ord River in the north to the Murchison River in the west. The rainfall decreases from 30 inches in the north to about 6 inches per year on the Murchison.

The towns in this vast territory of 500,000 square miles number about a dozen, being, with very few exceptions, either settlements around stamp batteries on a gold-field, or ports leading to them. The country, however, contains numerous sheep and cattle stations.

The Kimberley region contains a one-time important gold-field, with its centre at Hall's Creek on the divide between the Ord and Fitzroy Rivers. Numerous cattle stations have been occupied along both these rivers; but the rugged region between them is almost entirely uninhabited by white settlers. Wyndham, at the mouth of the Ord River, Derby, on the estuary of the Fitzroy, and Broome are the only towns. From the latter, which is an important pearling centre and cattle port, starts the cable to Java.

Pearling extends northwards from Sharks Bay, where the pearl-shell is of a smaller and less valuable kind, to Broome—the commercial base of the industry.

The next centre of settlement is the Pilbarra region; it is noted for its pearls, mining, heat, and cyclones. Hereabouts the average rainfall is 15 inches per annum; yet there are many records of 20 inches falling in a few hours. Cossack and Condon are situated where the tropical tornadoes recurve and strike the coast. The hinterland also holds an unenviable record for heat.

The Pilbarra gold-fields, with centres at Marble Bar and Nullagine, and the Whim Creek Copper Mines have led to the development of the country. A railway is being built from Port Headland to Nullagine. Large areas can be supplied with water for stock by putting down shallow bores. Sheep are the principal stock depastured in this region. Many of the stations are worked almost entirely by aboriginal labour, so that the wages' bill is small.

The southern portion of this belt, comprising the basins of the Ashburton, Gascoyne, and Murchison, should logically be considered with the Desert Region, for the greater part of it has a rainfall of less than 10 inches per year. However, numerous sheep and cattle stations have been taken up, the stock being shipped from Onslow and Carnarvon.

Far inland from Geraldton are the gold-fields of Yalgoo, Murchison, and Peak Hill. A railway runs through Yalgoo, Mount Magnet, Cue, and Nannine, to Meekatharra.

(b) The Central or Desert Tableland.

The Desert Region includes most of the areas with a rainfall under 10 inches. It may be described under the heads :—

(1) The Desert Proper;
(2) The MacDonnell Ranges;
(3) The Gold-fields Region.

(i.) The Desert Proper.

This division of the Western Tableland is rectangular in shape, about 1,200 miles from west to east, and 650 from north to south. The Lake Eyre Basin (included in the Artesian Lowlands, p. 109) is of the same arid character; and, with this addition, the desert may be described as occupying the rectangle between Cossack and Boulia, on the north, and Southern Cross and Broken Hill, on the south. In fact, the proposed transcontinental railways from Southern Cross to Port Augusta and from Camooweal to Bourke, form two of its boundaries.

This region, with an area of 800,000 square miles, comprises more than one-quarter of the whole continent. It therefore merits study, in spite of

the fact that there are probably not a thousand white folk in it, excluding the miners in the south-western corner between Kalgoorlie and Laverton. Our knowledge is derived from explorers' records, such as those of Giles and Carnegie, and from later Government expeditions, such as that of Canning in 1906.

In the north-eastern portion the MacDonnell Ranges have been well described by the Horn scientific expedition, and these highlands are now sparsely settled; but the region extending from Oodnadatta to the Westralian gold-fields is still desolate.

Great additions to our knowledge of the western portion of the desert have resulted from the recent work of Canning and Talbot. The former opened a stock route from Wiluna to the pastoral holdings near Hall's Creek. This distance of 700 miles is now supplied with permanent water by 50 shallow wells. Mr. Talbot has lately made a geological traverse along the stock route. He describes the country generally as flat, but diversified by low ranges; the prevailing south-west winds have banked sand ridges against the southern slopes of these ranges, but on the lee sides they are often flanked by a strip of flat country which in some places grows good feed for stock.

Although at some future time the lower portions of Sturt Creek may become settled, Mr. Talbot thinks that the country along the stock route south of that point is never likely to become occupied by pastoralists.

The heart of the arid region has been described by Carnegie. In 1896 he left the Coolgardie gold-field to strike across the continent in a N.N.E. direction in the hopes of finding gold-bearing or pastoral country in the great desert. Travelling over a long stretch of dry country in which the camels were without water for thirteen and a half days, they reached a soakage near Alexander Springs. Beyond this a few low sandstone ranges and hills were found, and occasionally in the valleys belts of bloodwood and a few shrubs edible by camels, but most of the country was a continuous waste of sand ridges. They reached Hall's Creek and returned south along the South Australian border. He thinks that a stock route from the MacDonnell Ranges to the Coolgardie railway is possible in winter. The route from the ranges to the south-west is excellent as far as the border; from there it would be necessary to hit off the small oases which are met with near Mount Squires, Warburton Ranges, Blyth Creek, and Alexander Springs. In conclusion, he says of the area traversed on his journey (Fig. 15)—"We have demonstrated the uselessness of any persons (either pastoralists or miners) wasting their time and money in further investigation of that desolate region."*

(ii.) The MacDonnell Ranges.

This area of elevated land lies in the middle of the continent, and owing to the Horn exploring expedition of 1894 we know more about it than about many more accessible regions. The Cretaceous area between Lake Eyre and the southern ranges of the group consists of stony ("gibber") plains and of arid loamy tracts which support a sparse saltbush flora. Professor Spencer calls these the Lower Steppes.

* D. W. Carnegie, *Spinifex and Sand*, 1898.

As soon as the northern boundary of the Cretaceous area is passed (near Chamber's Pillar) a striking difference appears in the configuration of the country.

The rocks consist of sandstones and limestones, which have been folded at some ancient period into series of ridges and valleys running east and west These, after being worn down to a level surface, were elevated in quite recent geological times, and the rivers have cut out the extraordinary series of gorges and lateral valleys which form so striking a feature of the region.

The northern portion of the MacDonnell area consists of much older rocks, such as gneisses and schists, probably allied to those covering a large part of Western Australia. Associated with them are certain dykes of granite, with white mica (*muscovite*), the chief mines being near Mount Brassey, in the north-east of the ranges, where plates of mica 6 feet across have been obtained. They are sent by camel to Oodnadatta, and are exported for use in electrical works. In the same region is Arltunga, a gold-field which promised well some years ago, but it is heavily handicapped by its situation and surroundings.

To the west, as soon as the ranges are left behind, the monotonous sand-hill, mulga, and spinifex country commences and extends through Western Australia to Coolgardie.

It is to be feared that neither the cattle, mica, nor gold will lead to the prosperous settlement of Central Australia. The low rainfall (averaging only 6 inches per year over a considerable portion of the area) makes extensive pastoral occupation impossible, while 200 miles of transport to the railway at Oodnadatta—and thence 600 miles to Adelaide—will prevent the working of any but very rich mineral fields.

(iii.) THE GOLD-FIELDS REGION.

In Western Australia, nearly 400 miles inland from the coast, in a region which 25 years ago had been crossed only by a few explorers and prospectors, and where the rainfall is only 8 inches, is clustered an important community of mining men. The chief town, Kalgoorlie, has a population of 30,000, and the other large centres (Coolgardie, Kanowna, etc.) have a total of about 35,000. Until 1887 it was an uninhabited desert, like that already described, but in that year was discovered the Southern Cross field and in 1892 the Coolgardie fields.

At first the only water supply was obtained from small "soaks." Later portable condensers were used to separate the salt from water derived from holes dug in the salt lakes. Before the railway was opened the Government constructed along the route tanks which served as collecting grounds after occasional rains. Each of these held about a million gallons, and cost some £3,000. This uncertain supply is now superseded by wonderful waterworks which bring water from the wetter regions near the coast. Early in 1903 the present supply-line was completed, connecting a reservoir near Perth with Kanowna, 387 miles east of that town. On the Darling Ranges, near Perth, there is a rainfall of over 20 inches, and a weir across the Helena River (at Mundaring) impounds 400,000,000 gallons. Nine pumping stations elevate the water 1,313 feet to the Coolgardie distributing reservoir The pipe line (33 inches diameter) is laid on the surface close to the railway, and

at each of the pumping stations, roughly 40 miles apart, the water is elevated about 140 feet, whence it flows by gravity to the next station.

In 1894 the railway line to Southern Cross was completed and gradually extended, as the value of the gold-fields became assured, to Kalgoorlie in 1897, Menzies, 1899, and since then to Laverton (586 miles), in the north, and to Norseman, in the south.

The transcontinental railway from Kalgoorlie to Port Augusta (1,100 miles) is now (1913) under construction. The gauge is the standard 4 ft. 8½ in.; and the other links, Fremantle to Kalgoorlie and Port Augusta to Albury, will be altered to suit this gauge. The estimated cost of construction is £3,988,000.

This railway will serve an area comprising about 90,000 square miles, which can be considered favorable for pastoral development: but the main advantages accruing are due to the increased speed in mails between Europe, Western Australia, and Eastern Australia. The military aspect is also one of importance.

In Western Australia this new railway traverses auriferous country for 65 miles to Cardinia. Thence it passes over granite for 100 miles, and further eastward it reaches the "saltbush" country, which is characteristic of the Tertiary limestones.

This region has less than 10 inches rainfall, but in the limestones water can be reached by bores several hundred feet deep. Unfortunately, this water is usually brackish.

Within the South Australian border (461 miles) similar limestone country is traversed until the ancient rocks around Tarcoola are met with. Here are valuable gold deposits, and outlying sheep stations are situated near the proposed line at Wilgena and Coondambo. Lake Hart promises to become an important source of salt. Near Oakden Hills station it descends from the tableland into the Torrens rift, and crosses the head of Spencer's Gulf at Yorkey's Crossing, which is only 5 miles from Port Augusta.

(c) The South-west Temperate Region.

The South-west Temperate Region is a belt extending from Geraldton to Eucla. It lies between the 10-in isohyet and the sea, and is characterized by a winter rainfall increasing to the south-west. This portion of Western Australia contains the whole of the agricultural land in the State. It is estimated that there are 60,000,000 acres which are suitable for agricultural purposes. It carries, and will always carry, the bulk of the population of Western Australia.

For descriptive purposes, the South-west Province may be subdivided into three belts, which are absolutely controlled by the rainfall. These are—

(1) The Eastern Pastoral Belt;
(2) The Central Wheat Belt;
(3) The Western Timber Belt.

(i.) THE EASTERN PASTORAL BELT.

This belt, extending from Sharks Bay through Southern Cross and Norseman to the Bight, lies approximately between the 8 in. and 13 in. isohyets. It is eminently suited for sheep and cattle. Two great rabbit-proof fences

cross this area. One starting from the coast about 50 miles north of Geraldton runs east through Yalgoo and then due south to the coast about 100 miles east of Albany. The other is further east and extends from near Hopetoun north towards Sandstone, and thence to the coast north of Pilbarra. These fences are kept efficient by Government maintenance men, and they enable the squatter to cope successfully with the rabbit invasion from the east.

(ii.) THE CENTRAL WHEAT BELT.

This belt lies between the 13 in. and 20 in. isohyets. It extends from Ajana to Hopetoun. A strip of country to the east of Hopetoun will be found as suitable for wheat as Eyre's Peninsula in South Australia, but is not yet developed.

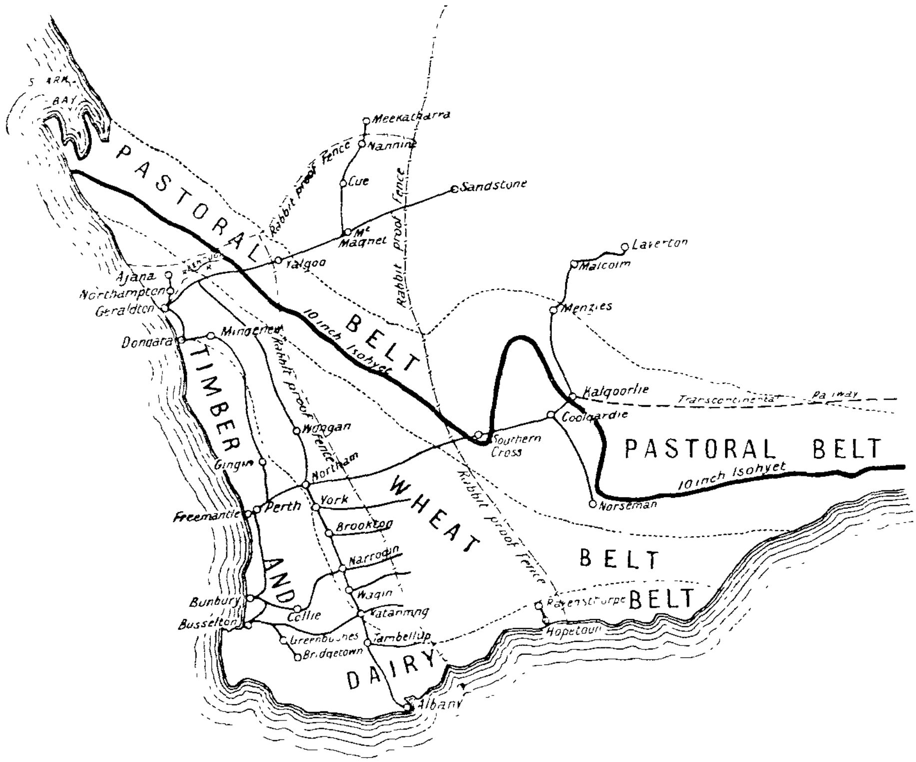

FIG. 16.—The South-West Province of the Westralian Plateau.

In the north are some rich river flats along the Greenough River. Here also are the Northampton copper mines. The belt of York gum (*Eucalyptus loxophleba*) and of white gum (*E. redunca*) is coincident with the wheat belt along its whole extent, though the timber is lighter in the north.

Geraldton and Dongara are the chief settlements in the north. Thence the Midland Railway through Mingenew and Gingin traverses the belt to Perth; while further east a new line through Wongan is under construction.

South of Northam a really tremendous development has gone on of late years. The Great Southern Railway to Albany runs along the west of

the wheat belt through York, Brooktown, Narrogin, Wagin, Katanning, and Tambellup. From each of these centres branch lines running east are completed or in progress; so that this portion of the wheat belt is served by one of the best railway systems in Australia.

(iii.) THE SOUTH-WEST TIMBER REGION.

To the westward of the trunk line the rainfall increases as the south-west coast is approached; the timber becomes heavier, until dense forests of commercial hardwoods are entered. Because of this, the wheat area does not extend very far westward, but the soil and rainfall are particularly well suited for oats; in parts for potato growing and root crops; and practically everywhere for fruit. This country is still to a great degree unoccupied, for farming in the wheat belt has yielded quicker returns than in these heavily-timbered districts. It is stated, however, that a farm of 160 acres in the west if wisely chosen and improved will provide as good a living as a 1,000-acre farm in the wheat belt.

All this country is or can be brought within convenient reach of the ports of Albany, Bunbury, or Busselton. Railways already cross it from Bunbury to Narrogin, through the coal-field of Collie. Another links Busselton to Katanning. A third passes through the tin-field of Greenbushes and opens up the forests of Bridgetown.

The whole of this western corner is clothed either in jarrah or karri, the latter occurring chiefly in a coastal belt 30 miles wide from Bridgetown to Albany. During 1910, timber to the value of £972,000 was exported.

Perth, the capital of Western Australia, lies in the north of this belt. It is situated on the estuary of the Swan River, and the hilly slopes on its western bank have been reserved as the King's Park. The Darling scarp—produced by the faulting of the coastal strip—is about 20 miles away to the east.

Fremantle lies at the mouth of the Swan, and in the vicinity of these two towns it is estimated that there are 108,000 people.

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CHAPTER IV.

CLIMATE OF AUSTRALIA.

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SYNOPSIS.

1. Introduction.

Until recent years Australia was regarded by most people as a land especially subject to severe droughts, and by more generous critics as a land of a feast or a famine.

Similar misconceptions of the true character of the country have to a greater or less extent been held in the developmental stages in the early histories of most lands, and in the colonization of newly discovered territories.

In Australia past failures and losses have been due to a variety of causes; amongst them may be enumerated a non-appreciation of the absence of natural water-storage, an ignorance of the adaptability of local soils and climate, unsuitable methods of working, a want of knowledge of the existence of an unlimited supply of artesian and sub-artesian waters, inadequate means of transit—both internal and external—and an uncertain market for products.

The staple product upon which Australia has developed is undoubtedly wool, and this item of commerce is still its chief export. We have not to go back many years to the time when the grower of wool was much in the dark as to the value of his crop.

The mutton was of very little value to the producer, the demand for such being entirely confined to our own small population. The wool was sent to the home markets entirely at the grower's risk, and the price he obtained for it there was quite problematical. The conditions being such, there was little incentive to make extensive monetary outlays for the conservation of water and fodder for the preservation of an asset of varying and uncertain value. Consequently when our seasonal dry periods came round (which are undoubtedly periods of soil rest), disaster was inevitable to a more or less extent.

Australia's commercial enterprise is on a very different basis now. With the perfection of refrigerating appliances, the meat markets of the world are open to it. The wool buyers of the world in competition give the highest current prices and relieve the grower of all responsibilities of transport to foreign markets. The squatter knows within narrow limits the value of his crop before it leaves the sheep's back. He therefore makes provision for preserving his stock, and conducts his enterprise on a business footing, in contrast with what was regarded in times gone by as a more or less speculative venture.

The extension of railways enables the squatter to move his stock from seasonal dry areas to synchronous wet ones. The sinking of artesian and sub-artesian bores and the storage reservoirs, both national and private, have rendered vast areas immune from the more serious effects of droughts in what, formerly, was precarious territory.

Finally it may be said that the demand for Australia's wool has become such a factor in the world's supply that if the clip is short the growers as a body reap compensation in the enhanced monetary value obtained.

This fact was exemplified during the 1911–1912 clip, when a great falling off in quantity took place, as a result of the severest drought known in our climatological history over the greater part of Australian wool-producing areas, yet the value of the wool nearly aggregated that of the previous season, which had been a fairly good one.

The vicissitudes of wheat growing tell much the same tale. The sowing of drought-resisting grain, dry farming methods, and scientific manuring have, however, brought the proposition of profitable wheat growing from the problematical to the actual stage.

The output has been steadily growing from year to year, and considering that nearly 500,000 square miles of the continent receive a sufficient average rainfall, *i.e.*, 10 inches and over during the wheat-growing period (April to October), the possibilities of future development in this direction are unlimited.

The climatic history and prosperity of the last ten years or so contradict emphatically the preconceived notion that Australia was the particular drought-stricken and precarious area of the earth's surface. The truth of the matter about Australia's rainfall is that—(1) it is generally ample for pastoral and agricultural industries over two-thirds of its area; (2) different regions have distinct seasonal dry and wet periods, which must be more fully recognised and industrial operations adapted accordingly; (3) it is subject in part, but never in the whole, to prolonged periods when the rainfall is short of the seasonal average. Australia is not peculiar in this respect. It follows, therefore, that as the so far undeveloped country becomes populated and put to profitable use, the general wealth of the community as a whole will steadily increase.

Striking illustrations supporting the above statement have been furnished by both Victoria and New South Wales since the beginning of this century. The losses due to shortage of rain in Gippsland during that period were largely mitigated by the returns from the newly-developed Mallee territory, and this wealth, be it said, was derived from a part of the State which was previously regarded as worthless.

South-eastern New South Wales, which in earlier times largely comprised the developed portion of the State, suffered its greatest falling off in aggregate rainfall during the same period, and, had it not been for agricultural and pastoral enterprise in the west and dairying developments on the north coast, would have experienced the effects of its record drought, instead of attaining as it did the zenith of its prosperity.

2. The Seasons.

The months of December, January, and February, constitute summer; March, April, and May, autumn; June, July, and August, winter; and September, October, and November, spring.

January is generally the hottest month and July the coldest, but February is the hottest month in the coastal areas of Victoria and throughout Tasmania; December the warmest month in Northern Queensland; November at Port Darwin; and January and December at Broome.

These anomalies in the northern parts of Australia are probably due to the cooling effects of the monsoon rains, which seasonally occur there during the late summer months.

3. Temperature.

Australia possesses the most pacific and equable climate of all the continents. This is due to its geographical position, the absence of physiographical extremes, and its insularity. Its most northern limit is 11 degrees from the equator, and its southern about 50 from the South Pole, distances sufficiently remote from both to temper the severity of heat and cold, to which is added the modifying effects of the intervening oceans.

Of its total area, 1,149,320 square miles are situated north of the tropic, and 1,825,261 square miles to the south of it. Thus it has a wide range of climate. In Queensland, the Northern Territory, and the northern portions of Western Australia, there is an unlimited opening for the growth of tropical products, such as rubber, cotton, sugar, etc. Suitable areas south of the tropic may be found for all temperate classes of vegetation, including fruit.

January and February are the two hottest months, the mean temperatures ranging from 80 to 85 degrees over all the northern and central regions, and to 65 degrees and 70 degrees over the southern areas. Owing, however, to the declining angle of the sun's rays and the advent of the seasonal monsoonal rains, these temperatures rapidly fall, until in July, the coldest month, a mean as high as 75 degrees is experienced only over a very narrow strip of the northern sea coast, that over the southern half being 55 degrees and under.

During the hot months of the year the climate on the coast, except in the south, is invariably enervating. Inland, however, life is generally enjoyable, although the thermometer may, in extreme cases, reach as high as 120 degrees in the shade, the dryness of the air and consequent rapid cooling of the skin by evaporation preventing serious discomfort when protected from the direct rays of the sun. Nocturnal radiation, too, as contrasted with that of coastal districts, is very active, so that the nights are invariably cool, and an absence of monotony of temperature tends to a bracing of the system and to good sleep at night.

During some seasons parts of the continent are subject to prolonged heat spells, as for example, at Marble Bar, a mining township in the north-west of Western Australia, where the maximum thermometer reached 100 degrees Fah. and over for 64 consecutive days in the year 1902. Nullagine, in the same region, recorded 100 degrees Fah. for 57 days in the year 1900; Boulia, in Western Queensland, 53 in 1902; Charlotte Waters, in the neighbourhood of Lake Eyre, 25 days in 1893; and Charleville, in Central Queensland, 20 days in 1893. Heat of this description is, however, confined to the interior The figures of the State capitals will serve for confirmation of this point. Perth has only experienced a maximum temperature of 90 degrees and over on 20 consecutive days; Adelaide, 14; Melbourne and Brisbane, 8; Sydney, 4; and Hobart, 3; and it may fairly be assumed that extremes of climate in this respect have practically been reached, as records have been kept

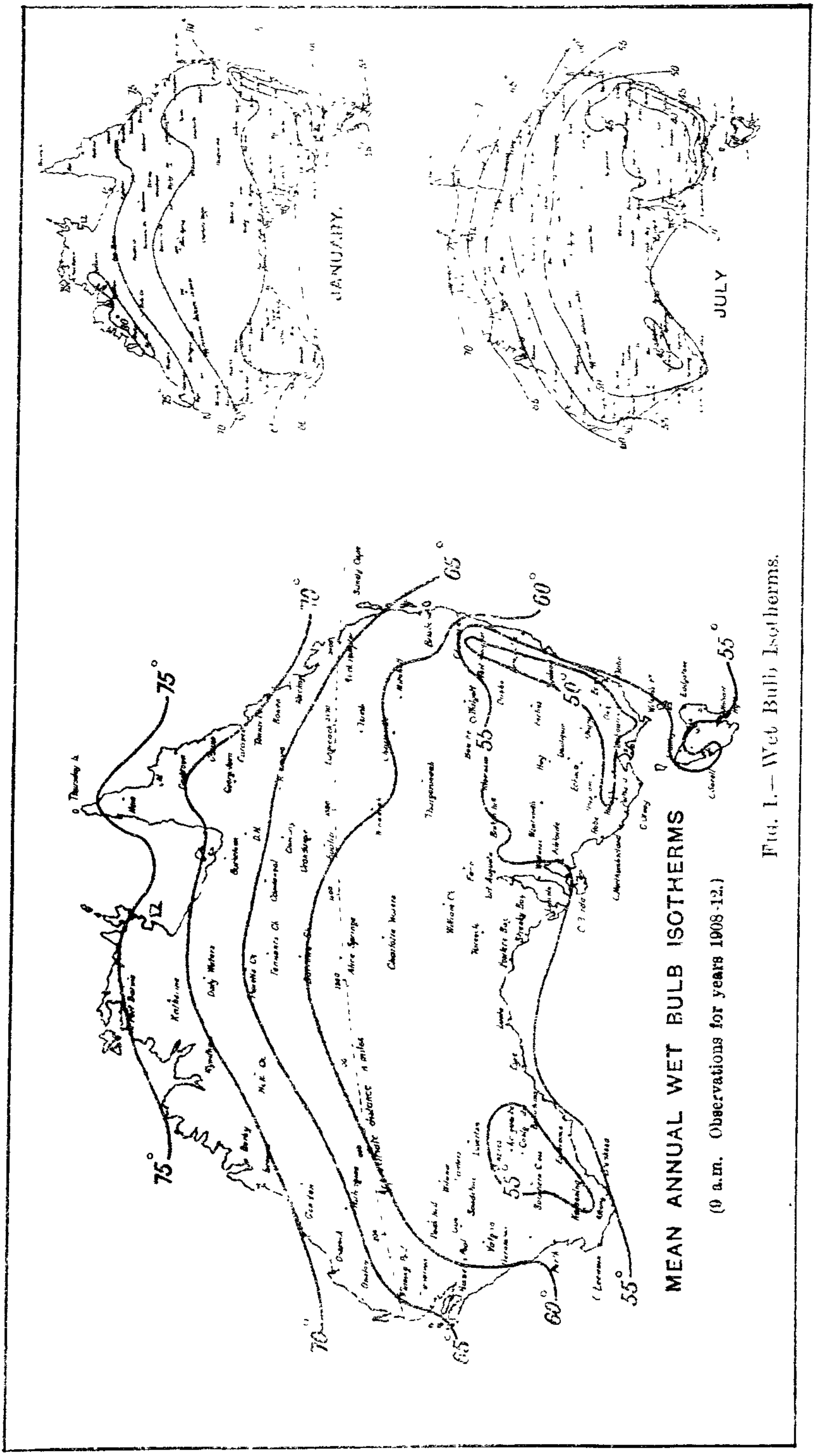
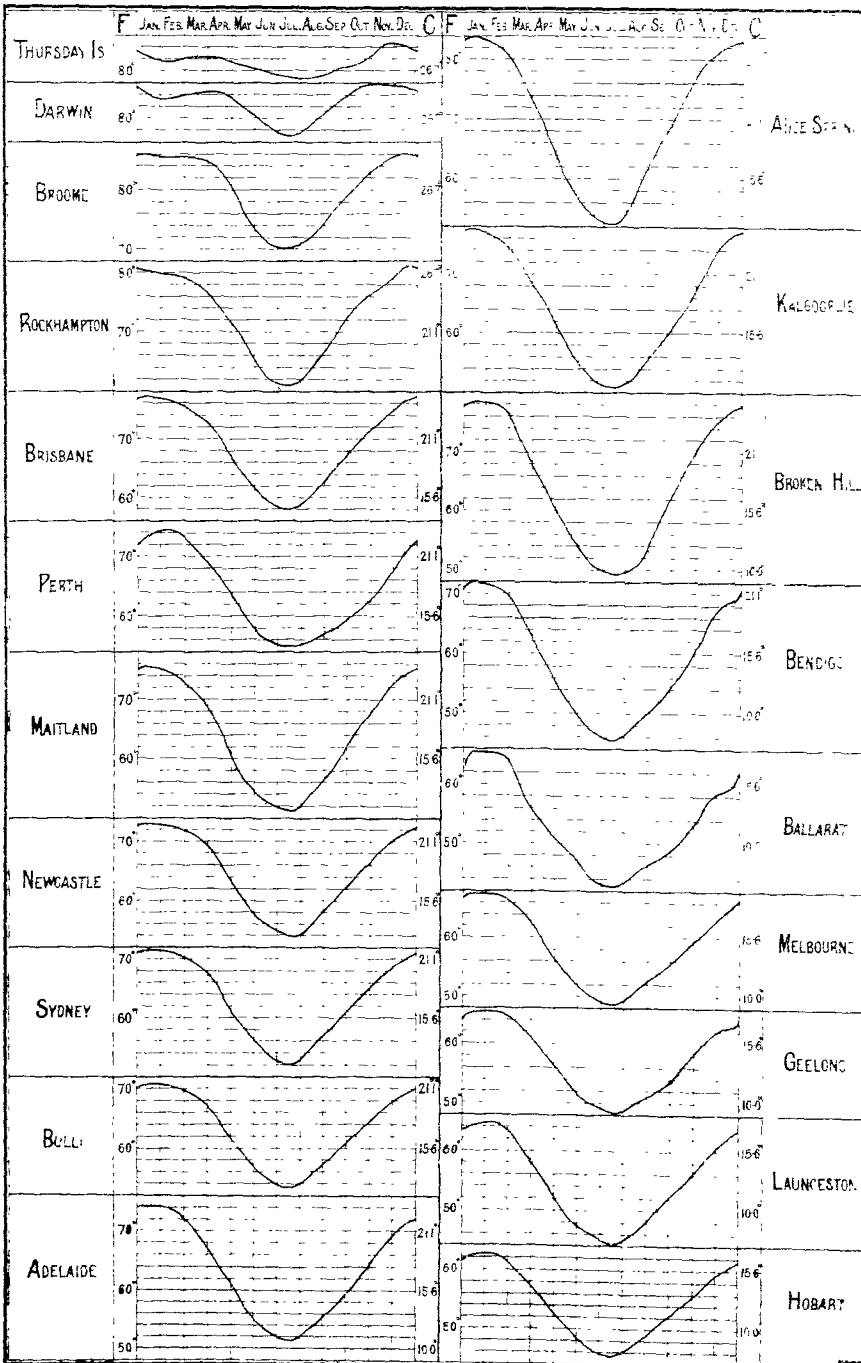


FIG. 1.—Wet Bulb Isotherms.

Graph showing Mean Monthly Temperatures of Principal Cities in Australia.



NOTE.—Each vertical space represents 2° Fahrenheit or 1·1° Centigrade.

FIG. 2.

at all the Observatories at these places, with the exception of Perth, for over half-a-century, a period sufficiently long for the establishment of temperature normals.

The foregoing remarks indicate that shade temperatures alone give only actual temperature as experienced by dry inorganic substances and not the sensible temperature as felt by organic bodies. This difference is due, as already stated, to cooling by the evaporation of moisture from the skin by wind and heat, but more especially by the action of wind. In order, therefore, to gauge the appreciable temperature of a country, it is necessary to use other instruments than the ordinary maximum and minimum thermometers. The principal additional instrument requisitioned for the desired end is the wet bulb thermometer.

A number of these have been distributed throughout Australia for the purpose of showing the disposition and trend of the wet bulb isotherms. Although the period over which observations have extended is not long enough to determine definite normals, yet sufficient records have been obtained to fairly establish the influence of this climatic element. At the outset it may be said that in no part of Australia is the wet bulb temperature maintained at a reading sufficiently high to be detrimental to the health and physique of those engaged in outdoor labour.

Investigations so far carried out confine the 80-degree Fah. wet bulb isotherm to a very narrow track of country on the north-west coast of Western Australia during the months of December, January, and February.

The 70-degree Fah. isotherm only extends to sub-tropical latitudes over comparative small areas in Queensland and Western Australia during the same months and March, while in southern Australia the readings are from 50 degrees to 70 degrees.

The accompanying table and graph show the average monthly and annual temperatures at a number of representative centres of the Commonwealth.

Broome, Port Darwin, and Thursday Island are the hottest of these, and have an annual average range of 16·6 degrees, 8·3 degrees, and 5·5 degrees respectively. The last-named is undoubtedly the most monotonously warm place of the continent.

Of the capital cities Brisbane is the hottest and Hobart the coldest, the others taking order between them as follows:—Perth, Sydney, Adelaide, and Melbourne. The annual average range between the hottest and coldest months is about 20 degrees in all these places.

Taking Kalgoorlie and Broken Hill to represent conditions in the interior, we naturally find the extremes are much greater—Broken Hill's maximum of 78·4 degrees in January falls to a minimum of 49·2 degrees in July, a range of 29·2 degrees; and Kalgoorlie's 77·5 degrees in January to 50·8 degrees in July, a range of 26·7 degrees.

In sub-tropical areas insolation is more active over the eastern half than over the western during the early summer months, and more active over parts of the western coastal districts during the late summer months.

In eastern Australia, too, the temperatures in the sub-tropics are about 1 degree higher than in corresponding latitudes in the west. North of the tropic these conditions are reversed, and between latitudes 17 degrees to 20 degrees the difference in excess is as much as 10 degrees in favour of the west coast.

TABLE OF MEAN MONTHLY AND ANNUAL TEMPERATURES AT CAPITALS AND PRINCIPAL TOWNS IN THE COMMONWEALTH.

City.	Latitude.	Longitude.	Height.	Distance from Coast.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
	S.	E.	Feet.	Miles.	°	°	°	°	°	°	°	°	°	°	°	°	°
Port Darwin	12° 28′	130° 51′	97	..	84·0	83·4	81·2	84·4	81·9	79·0	77·1	79·3	82·7	85·5	85·8	85·4	82·7
Broome	17° 57′	122° 15′	34	..	85·9	85·1	85·4	83·1	76·4	71·2	71·3	72·4	77·0	81·0	84·6	85·9	79·9
Perth	31° 57′	115° 51′	197	12	73·6	74·2	71·2	66·4	60·4	56·2	55·0	56·0	57·9	60·9	65·4	70·6	64·0
Kalgoorlie (Coolgardie)	30° 45′	121° 30′	1,261	387	77·5	76·0	71·6	65·4	57·6	52·3	50·8	53·4	58·4	63·6	70·9	76·2	64·5
Alice Springs	23° 38′	133° 37′	1,926	576	84·0	82·3	76·7	68·1	59·7	54·3	52·5	58·3	65·6	73·5	79·5	82·4	69·7
Adelaide	34° 56′	138° 35′	140	6	74·2	73·9	69·9	64·0	57·7	53·4	51·5	53·8	57·0	61·9	67·1	71·1	62·9
Broken Hill .. .	30° 58′	141° 21′	1,001	220	78·4	77·9	71·8	63·9	56·6	51·0	49·2	52·8	58·4	65·8	73·0	76·6	64·6
Bendigo	36° 46′	144° 17′	825	73	71·9	70·9	66·5	59·0	52·2	47·6	45·5	48·5	51·8	57·3	64·3	68·5	58·7
Ballarat . .	37° 33′	143° 52′	1,430	46	65·3	65·2	59·4	53·2	49·0	44·1	42·6	45·3	47·5	50·7	56·9	59·0	53·2
Geelong . ..	38° 10′	144° 21′	90	1	65·3	65·4	62·7	58·7	53·7	50·2	48·3	50·1	51·9	55·9	60·5	62·7	57·1
Melbourne .	37° 50′	144° 59′	115	3	67·5	67·3	64·6	59·5	54·1	50·3	48·1	51·0	54·0	57·5	61·3	64·6	58·3
Hobart	42° 53′	147° 22′	160	1	62·4	62·4	59·5	55·1	50·4	46·8	45·3	47·7	50·8	53·9	57·5	60·3	54·3
Launceston .. .	41° 27′	147° 10′	33	32	64·1	64·5	60·6	55·5	49·1	46·5	44·1	46·3	50·2	53·9	58·2	62·0	54·6
Canberra .. .	35° 20′	149° 15′	1,910	60	67·6	68·0	63·8	55·3	49·6	44·0	44·0	46·2	49·8	52·8	61·4	64·0	55·5
Bulli (Wollongong) ..	34° 25′	150° 56′	33	..	70·8	70·4	68·6	64·1	59·2	55·1	53·6	55·8	59·4	63·0	66·2	69·0	63·0
Sydney	33° 52′	151° 12′	146	5	71·6	71·0	69·2	64·5	58·6	54·3	52·3	54·8	58·8	63·4	67·0	70·0	63·0
Newcastle .. .	32° 55′	151° 49′	112	1	73·0	72·4	71·0	66·4	60·3	56·0	54·0	56·2	60·4	64·9	68·6	71·5	64·6
Maitland ..	32° 45′	151° 35′	19	18	75·6	74·2	71·0	64·7	56·8	53·1	51·3	54·2	59·1	65·3	70·4	74·2	64·2
Brisbane . ..	27° 28′	153° 2′	137	10	77·1	76·4	74·3	70·2	64·4	59·9	58·0	60·6	65·2	69·8	73·3	76·5	68·8
Rockhampton . .	23° 24′	150° 30′	37	18	80·2	79·6	78·3	74·0	69·0	62·6	61·0	64·2	69·7	74·9	77·8	81·2	72·7
Thursday Island .. .	10° 34′	142° 12′	17	..	82·2	81·5	82·3	82·2	81·1	79·8	79·0	78·8	80·2	81·2	84·4	84·1	81·3

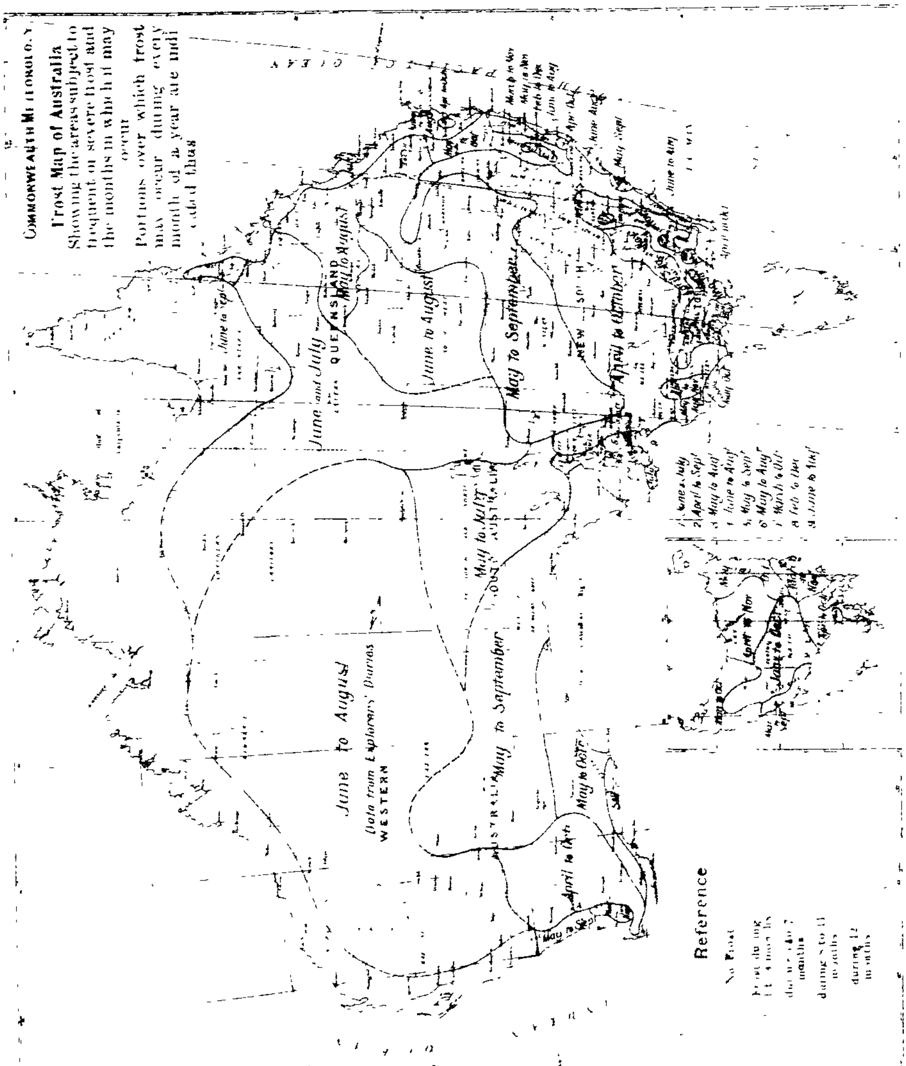


FIG. 4 — Frost Map.

4. Frosts.

Although observations have been taken continuously for a great number of years, no notes of appreciable frosts have been recorded over all the northern coastal regions extending from Geraldton on the west coast right round the north and east coasts to Brisbane. The same remark applies to Northern Territory.

In all other parts of Australia, however, night frosts are severe and frequent, although of considerably varying periods.

On the highlands in New South Wales, Victoria, and Tasmania, frosts of a more or less damaging nature have occurred in every month of the year. Over a stretch of country largely comprising the wheat areas of South Australia, Victoria, New South Wales, and Queensland, they have been recorded between April and October.

Over north-central and north-east Victoria, the south and central western slopes of New South Wales, from April to November; over the Gascoyne and north-eastern parts of Western Australia and Central Australia from June to August.*

In central and western Queensland from June to July, June to August, or May to August.

Over the southern portion of Western Australia from April to October, or May to September.

For details of frost periods and distribution, see Fig 4

5. Rainfall.

Sources of Rainfall.

The two main sources of Australian rainfall are the southern depressions which skirt the southern shores of the continent mainly during the winter months, and the tropical low pressure which operates chiefly in the summer months.

A secondary but important source of supply is the anticyclone, which by inducing a flow of moist air from the adjacent ocean waters at any time during the year may bring about copious rains over the eastern littoral.

The minor sources of rain are those of cyclones and tornadoes, but although these storms are characteristic of the country and result in heavy downpours, they cannot be regarded as staple or widespread givers of rain.

Physical Causes of Rain.

The condensation of water vapour into visible cloud form in the atmosphere is brought about generally by cooling. There are several known processes by which condensation results, and there may be other physical causes which give rise to the same effect, notably atmospheric electricity, but which are not at present properly understood.

These may be enumerated as follows:—

(1) The meeting of cold and warm currents of air forming condensation known as fog.

(2) Condensation by ascending currents due to convection.

(3) Condensation by forced ascending current, *i.e.*, air forced from the sea to the rising sea shore and up the sides of hills and mountains.

* These data were largely gathered from explorers' diaries.

(4) Condensation by falling barometric pressure.
(5) Condensation by atmospheric wave
(6) Condensation by radiation.
(7) Condensation due to conduction.
(8) Condensation by diffusion of water vapour.

These processes have only to be continued sufficiently long for precipitation to take place either in the form of rain, snow, or hail.

The above definitions may be found in most meteorological text-books, and are only repeated here to emphasize the fact that one of the most important processes, at all events as far as it applies to Australian Meteorology, has hitherto been generally overlooked, and that is the movement of air from warm to cool latitudes and zones causing condensation and finally bounteous precipitation over vast areas, with more or less disregard to the influence of land elevation or of barometric fluctuations.

During the present year, 1913, many examples of this phenomenon have occurred, and the break up of the dry spell over eastern Australia in June, 1912, was a conspicuous one.

The characteristic isobaric conditions which precede or accompany this form of rain production are anticyclones of great dimensions and of considerable intensity, covering the eastern half of Australia, and perhaps an equal area of the ocean to the east. Their western isobars are comparatively straight, extending from the Indian Ocean east from the meridian of Port Darwin to the Southern Ocean east of Spencer's Gulf. The following and attending areas of the low pressure generally take the form of a shallow trough or valley in the atmosphere extending through the centre of Australia from the northern to the southern seaboards. It will thus be seen that a direct and rapid wind circulation control extends from the equatorial zone to temperate latitudes resulting in conditions particularly favorable for widespread and heavy downpours.

The rainy season in Western Australia may be said to result almost solely from this physical action.

The rain-bearing winds are northerly, precipitation becoming heavier as higher latitudes are reached.

Over Papua the reverse action takes place; during the dry season the winds are strong and persistent from the south-east quarter, blowing from cool to warmer latitudes. The water vapour carried by these winds is therefore expanded instead of precipitated.

On the occasion of the rain storm of June, 1912, it is estimated from this cause of precipitation that an inch of rain on the average fell over an area approximating 1,000,000 square miles of eastern Australia, or a weight of water roughly equivalent to $1,000,000 \times 640 \times 100 = 64,000,000,000$ tons.

The knowledge that rain visitations of this character are not infrequent completely dispels the preconceived notion of Australia being a particularly dry area of the earth's surface, and shews that although our rain seasons may be irregular, yet relief from dry spells may occur, as in the case quoted,

at times long after the normal period for rain has passed. This peculiarity is a great advantage and a happy feature of Australian climate; and very different from conditions, say, for example, that obtain in India—where, if the monsoon season fails to bring rain, very little hope of relief can be looked for.

Before finally leaving this point, it may definitely be accepted that any isobaric distribution that controls a strong wind circulation from warm to cool areas, more especially from warm to cool latitudes, will bring about good rains, and, moreover, that the recurrence of such isobaric distributions are typical events of good seasons. (See Fig. 5.)

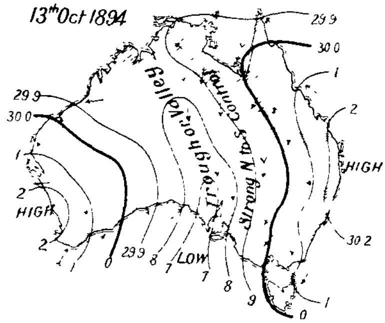


Fig. 5.—Isobaric Distribution (wet type).

On the other hand, extensive isobaric distributions that control a wind circulation from cool to warm zones or latitudes, or that control a wind circulation along parallels of latitude, will bring little or no rain except in opposing coastal areas. These distributions predominate during and are typical of a dry season. (See Fig. 6.)

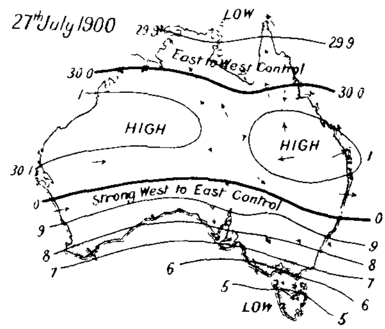


Fig. 6.—Isobaric Distribution (dry type).

6. The Normal Monthly Distribution of Rain.

A set of charts illustrating the monthly progress of rainfall in Australia has recently been published. Those of January and July, together with one for the whole year, are here reproduced. They were compiled from data extending over a considerable period, generally from 20 to 40 years (there being only a few stations with a minimum of fifteen years' record), so that the isohyets are likely to suffer little modification in the future.

A casual glance at the series reveals three marked facts—(1) that during the hotter months, viz., November to April inclusive, the northern parts of Australia are wet and the southern dry; (2) that during the colder months viz., May to October inclusive, the southern parts are wet, and the northern dry; (3) that the rainfall is distributed fairly generally throughout the year over the eastern areas of Australia.

During January and February fully three-fourths of the continent, comprising the whole of the northern and eastern areas, are wet, while the central, southern, and south-western portions are distinctly dry. In March, there is a general retreat northward of the rainfall area to the extent of 200 miles in Western Australia, a slight extension westward in the south-east quarter of the continent, and in Western Australia the 1-in. isohyetal appears on the extreme south-west coast.

In April the northern rain area retreats in central Australia from the tropic to within 300 miles of the north coast, although still lagging over the north-west coast of Western Australia and the Murchison gold-fields.

In the south a decided westerly extension takes place from the south-eastern States to South Australia and Western Australia, the 1-in. isohyetal sweeping continuously around the southern shores with the exception of a short break at the head of the Great Bight.

The northern rain entirely disappears in May, and the southern extends up the west coast of Western Australia to within a few miles of Cossack, and the quantities increase as compared with those of the previous month by 4 inches in the extreme south-west corner.

June, the wettest month of the year for southern Australia, shows a complete reversal of January rain conditions. In Western Australia precipitation is general during this month west of a line joining Derby and Eyre and in South Australia the 1-in. isohyet reaches its furthest northern limit in close proximity to Farina.

From July to December it may be remarked that the rain area as a whole swings back in the opposite direction to its march during the first six months.

On the west coast the 1-in. line steps back to Onslow in July; to Hamelin Pool in August; to Geraldton in September; still farther south in October; and all but disappears in the extreme south-west in November; so that little or nothing is left in December. While this retreating process is taking place in the west, a corresponding advance movement is going on in the east. Between the end of June and the end of August there is little change, but from September to the end of the year the expansion of area and quantity of rain increases rapidly. October shows the return of the monsoon rain in Northern Territory. In November it has penetrated 450 miles further into the interior and connected up with the permanent rain area over eastern Australia.

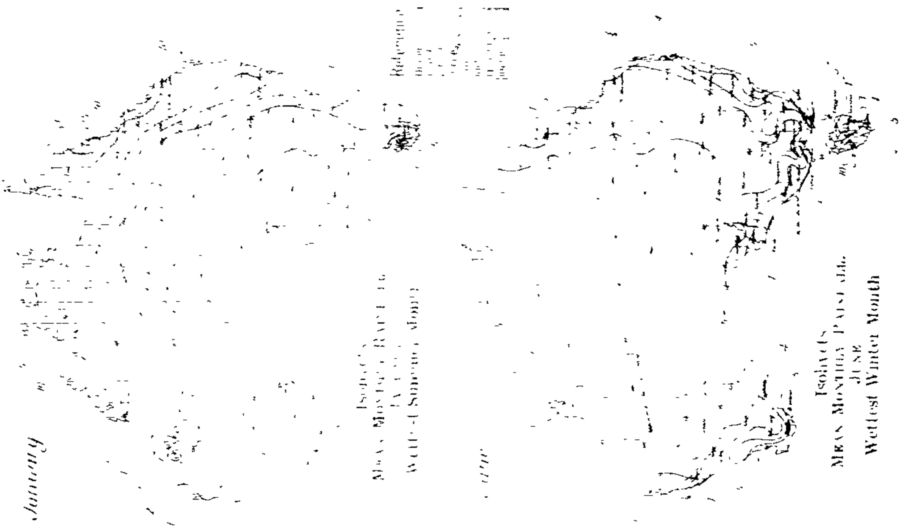
In December, the monsoon rain covers practically the whole of the continent north of the Tropic, and east of the 144th meridian.

We find, therefore, that there exists apparently an oscillatory movement of the seasonal rains of Australia about a centre in the vicinity of Forbes, in New South Wales. It is perhaps a natural coincidence that this apparent centre of oscillation is approximately the centre of gravity of Australia's population, and is not far from the Federal capital site; another interesting point is that the amplitude of oscillation exactly equals 72 degrees of arc or one-fifth of a circle.

7. Wettest Months.

Roughly speaking, June is the wettest month over that portion of Australia lying to the south of a line joining Onslow on the north-west coast of Western Australia and Sydney on the east coast.

To the north of that line, January commands the greatest claim as the wettest month, although February runs it very closely over a wide belt of country extending from the lower Northern Territory through south-west Queensland to northern parts of New South Wales. March also is the



Isohyets
Mean Monthly Rainfall
January
Wettest Summer Month

Isohyets
Mean Monthly Rainfall
June
Wettest Winter Month

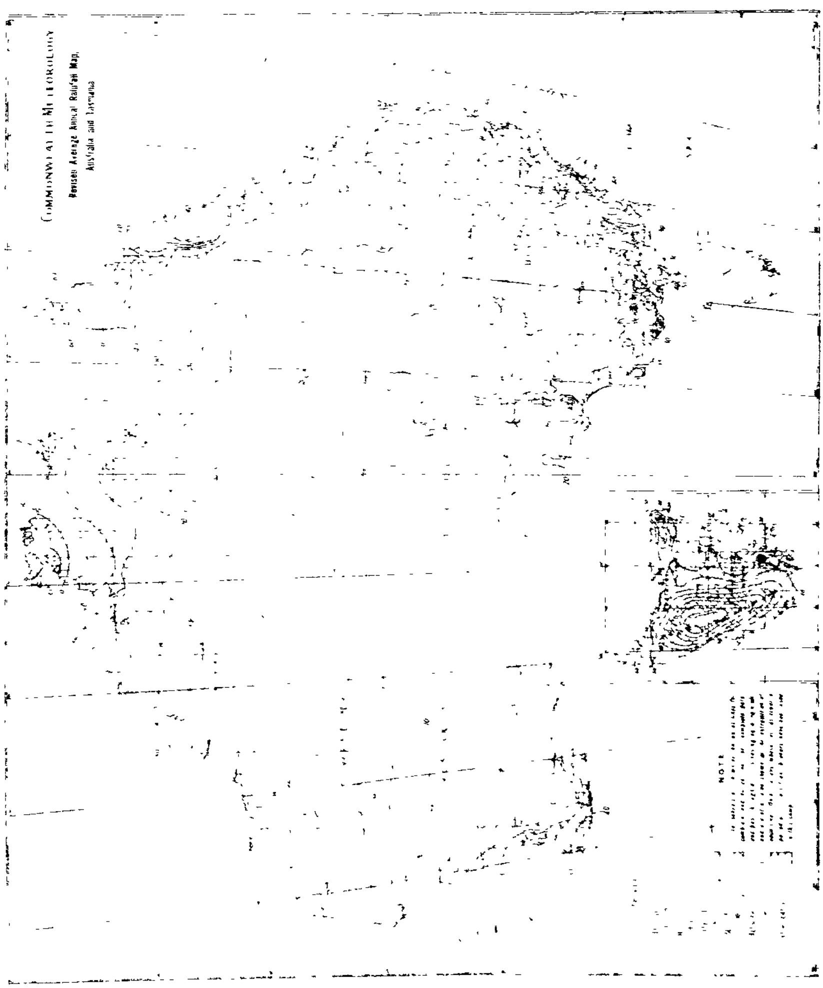
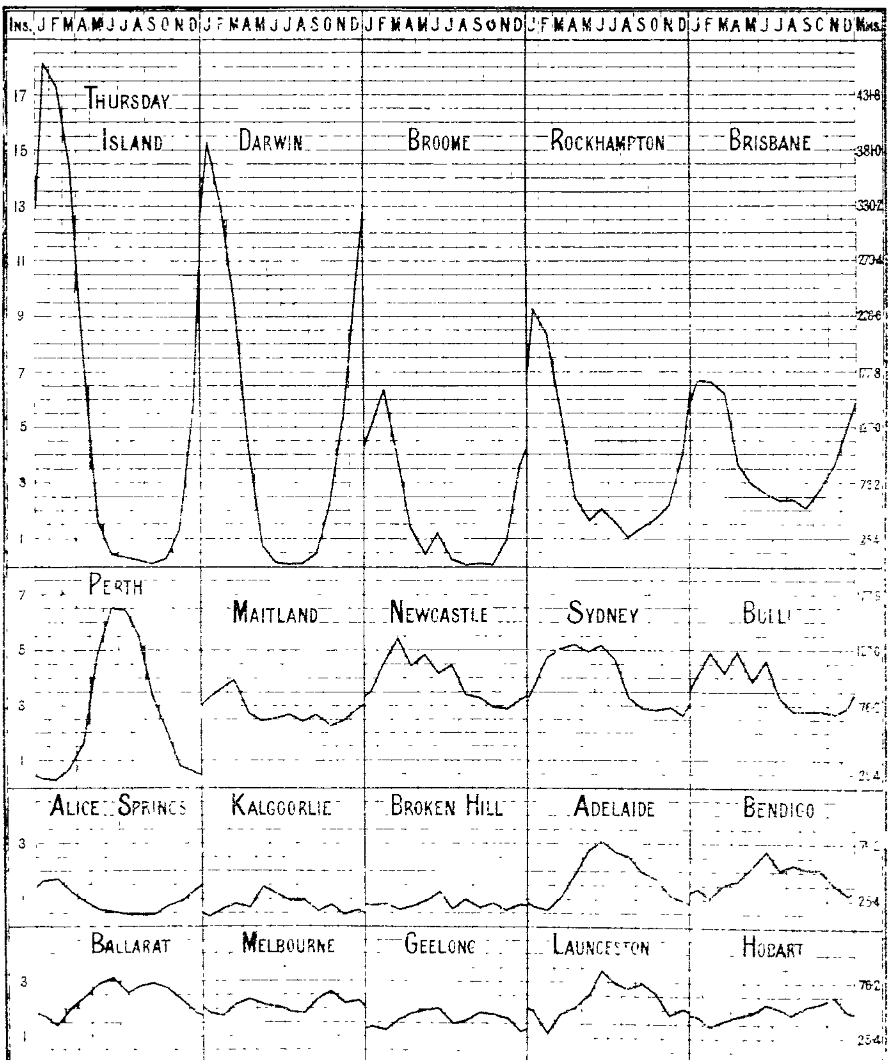


FIG. 7.—Rainfall Map.

Graph showing Mean Monthly Rainfall of Principal Cities in Australia.



NOTE.—Each vertical space represents ·5 of an inch or 12·7 millimetres.

FIG. 8

wettest month in parts of central Queensland, parts of central New South Wales, and over a comparatively small area on the north-west coast of Western Australia.

As would naturally be expected, at the junction of the summer and winter rains, which is represented by the line above mentioned crossing the continent from north-west to south-east, the wettest month is somewhat indeterminate. This point is particularly noticeable in the State of New South Wales, through which the line centrally passes, for within its boundaries every month with the exception of September is represented as the wettest month in some part or other, with a preponderance, as before stated, for June in the southern half, and January, February, and March in the northern half, as the months of heaviest total falls.

HEAVY RAINFALLS, WESTERN AUSTRALIA.

Name of Town or Locality.	Date	Amount
		inches
Ascott ..	8 Feb., 1912..	8·85
.. ..	9 Feb., 1912..	5·85
Balla Balla	20 Mar., 1899	6·00
..	21 Mar., 1899	14·40
Bamboo Creek	22 Mar., 1899	10·10
Boodarie	3 Jan., 1894..	10·03
..	4 Jan., 1894..	5·22
..	21 Mar., 1899	14·53
..	6 Feb., 1901..	1·91
..	7 Feb., 1901..	9·16
Carlton ..	11 Jan., 1903	10·64
.. ..	8 Feb., 1912..	9·05
.. ..	9 Feb., 1912..	3·15
Cherrabun	28 Apr., 1910	2·90
..	29 Apr., 1910	7·78
Cocos Island	29 Nov., 1903	14·38
..	26 Dec., 1907	8·00
..	27 Dec., 1907	2·65
..	8 July, 1908.	10·21
..	9 July, 1908..	2·75
..	23 July, 1908	2·40
..	24 July, 1908	7·00
..	25 July, 1908	3·85
..	6 Oct., 1910.	12·70
Cossack	3 Apr., 1898..	12·82
..	15 Apr., 1900	6·89
..	16 Apr., 1900	13·23
Croydon	3 Mar., 1903	12·00
De Grey	3 Jan., 1894..	9·75
Derby ..	29 Dec., 1898	13·09
.. ..	30 Dec., 1898	7·14
Fortescue	3 May, 1890	23·36
Indee ..	22 Mar., 1890	5·08
,,	23 Mar., 1890	5·40
Kerdiadary	7 Feb., 1901..	12·00
La Grange	20 Dec., 1905	3·70
La Grange ..	21 Dec., 1905	7·61
Millstream ..	5 Mar., 1900	10·00
Obagama ..	16 Feb., 1896	3·95
,,	17 Feb., 1896	6·30
,,	18 Feb., 1896	7·22
,,	28 Feb., 1910	12·00
Point Cloates ..	20 Jan., 1909	10·87
Point Torment	17 Dec., 1906	11·86
Port Hedland	7 Feb., 1901..	3·56
,, ..	8 Feb., 1901..	9·55
Quanbun ..	29 Apr., 1910	6·55
,,	30 Apr., 1910	3·40
Roebourne ..	3 Apr., 1898..	11·44
,, ..	6 Mar., 1900	10·32
Tambrey	.. ,,	11·00
,, ..	3 Mar., 1903	10·47
Thangoo ..	17–19 Feb., 1896	24·18
,, ..	28 Dec., 1898	11·15
,, ..	20 Nov., 1910	7·40
,, ..	21 Nov., 1910	4·56
Whim Creek	2 Apr., 1898..	7·08
,, ..	3 Apr., 1898..	29·41
,, ..	20 Mar., 1899	8·89
,, ..	21 Mar., 1899	18·17
,, ..	6 Mar., 1900	10·32
,, ..	3 Mar., 1903	10·44
Woodstock ..	21 Mar., 1913	13·00
Wyndham ..	27 Jan., 1890	11·60
,, ..	11 Jan., 1903	9·98
,, ..	12 Jan., 1903	6·64
,, ..	13 Jan., 1903	4·20
Yeeda	28 Dec., 1898	8·42
,, ...	29 Dec., 1898	6·88
,, ...	30 Dec., 1898	6·12

HEAVY RAINFALLS, SOUTH AUSTRALIA.

Name of Town or Locality.	Date.	Amount	Name of Town or Locality	Date.	Amount
		inches			inches
Arltunga	1 Mar., 1910	1·02	Port Darwin	7 Jan., 1897	11·67
,,	2 Mar., 1910	1·42	,,	26 Dec., 1911	1·42
,,	3 Mar, 1910	7·77	,,	27 Dec., 1911	7·87
,,	4 Mar., 1910	1·85	,,	28 Dec., 1911	2·06
,,	5 Mar., 1910	1·24	Powell's Creek	25 Feb., 1910	2·31
Borroloola	14 Mar., 1899	14·00	,,	26 Feb., 1910	1·21
Lake Nash	21 Mar., 1901	10·25	,,	27 Feb., 1910	8·19
Pine Creek	8 Jan., 1897	10·35	Tennant's Creek	26 Feb., 1910	1·18
Point Charles	30 Jan., 1913	4·46	,,	27 Feb., 1910	1·02
,,	31 Jan., 1913	5·60	,,	28 Feb., 1910	9·22

HEAVY RAINFALLS, QUEENSLAND.

Name of Town or Locality.	Date	Amount	Name of Town or Locality	Date	Amount
		inches			inches
Anglesey	26 Dec., 1909	18·20	Cairns	5 Apr., 1891	14·08
Ascot	14 Mar., 1908	11·34	,,	9 Jan., 1892	10·56
Ayr	20 Sept., 1890	14·58	,,	4 Jan., 1909	11·56
,,	25 Mar., 1891	10·19	,,	3 Jan., 1911	11·97
,,	26 Jan., 1896	10·50	,,	11 Feb., 1911	15·17
Babinda	17 Mar., 1912	10·15	,,	17 Mar., 1911	10·35
Beenleigh	21 Jan., 1887	11·30	,,	1 Apr., 1911	11·71
,,	14 Mar., 1908	10·40	,,	2 Apr., 1911	20·16
Bloomsbury	14 Feb., 1893	17·40	Caloundra	21 Jan., 1887	10·50
,,	27 Jan., 1896	10·52	Cape Capricorn	17 Jan., 1905	10·16
,,	10 Jan., 1901	16·62	Cape Grafton	5 Mar., 1896	13·37
,,	4 Mar., 1906	11·36	Cardwell	18 Mar., 1887	10·15
,,	9 Jan., 1908	11·30	,,	30 Dec., 1889	12·00
Boggo-road Junction	14 Mar., 1908	10·42	,,	2 Jan., 1890	10·06
			,,	23 Mar., 1890	12·00
Botanic Gardens, Brisbane	,, ,,	10·80	,,	18 Mar., 1904	18·24
			,,	3 Apr., 1911	12·84
Bowen	13 Feb., 1893	14·65	,,	7 Apr., 1912	11·90
,,	20 Jan., 1894	11·11	Cedar Pocket	26 Dec., 1909	11·36
Bowen Park	16 Feb., 1893	10·38	Central Kin Kin	,, ,,	10·17
,,	14 Mar., 1908	11·50	Chiefswood	14 Mar., 1898	11·01
Brisbane	21 Jan., 1887	18·31	Childers	6 Mar., 1898	11·28
,,	14 Mar., 1908	11·18	Clare	26 Jan., 1896	15·30
Bromby Park (Bowen)	14 Feb., 1893	13·28	Cleveland	13 Jan., 1910	10·13
			,,	2 June, 1910	11·20
,, ,,	20 Jan., 1894	11·20	Coen	20 Apr., 1903	11·11
Brookfield	14 Mar., 1908	14·95	,,	1 Apr., 1910	10·71
Buderim Mountain	11 Jan., 1898	26·20	Collaroy	30 Jan., 1896	14·25
,, ,,	9 Mar., 1898	11·10	,,	30 Jan., 1910	10·25
Bulimba (Brisbane)	16 Feb., 1893	10·40	Cooktown	22 Jan., 1903	12·49
Bundaberg	31 Jan., 1893	10·15	,,	19 Jan., 1907	11·70
Burketown	15 Jan., 1891	13·58	,,	1 Apr., 1911	11·11
,,	12 Mar., 1903	14·52	Cooran	1 Feb., 1893	13·62
Bustard Head	18 Feb., 1888	10·14	,,	9 June, 1893	10·12
,,	30 Jan., 1893	11·85	,,	26 Dec., 1908	14·08
Caboolture	21 Jan., 1887	10·00	Cooroy	9 June, 1893	13·60
,,	10 Jan., 1898	10·28	,,	10 Jan., 1898	13·50
Cairns	11 Feb., 1889	14·74	,,	6 Mar., 1898	10·04
,,	21 Apr., 1889	12·40	Cressbrook	16 Feb., 1893	10·65

HEAVY RAINFALLS, QUEENSLAND—*continued*.

Name of Town or Locality.	Date.	Amount	Name of Town or Locality.	Date.	Amount
		inches			inches.
Crohamhurst (Blackall Range)	31 Jan., 1893	10·78	Goondi Mill (near Innisfail)	25 Jan., 1892	11·10
,, ..	2 Feb., 1893..	35·71	,, ..	6 Apr., 1894..	15·69
,, ..	9 June, 1893	13·31	,, ..	7 Mar., 1899	10·08
,, ..	9 Jan., 1898..	19·55	,, ..	18 Apr., 1899	14·78
,, ..	6 Mar., 1898	16·01	,, ..	24 Jan., 1900	13·30
,, ..	26 Dec., 1909	13·85	,, ..	6 Jan., 1901..	10·70
Crow's Nest ..	2 Aug., 1908	11·17	,, ..	2 Mar., 1901	10·67
Croydon ..	29 Jan., 1908	15·00	,, ..	29 Dec., 1903	17·83
Cryna (Beaudesert)	21 Jan., 1887	14·00	,, ..	17 Mar., 1904	10·00
Dungeness ..	16 Mar., 1893	22·17	,, ..	21 Mar., 1910	10·38
,, ..	19 Jan., 1894	11·84	,, ..	10 Feb., 1911	17·68
,, ..	17 Apr., 1894	14·00	,, ..	31 Mar., 1911	12·38
Dunira	9 Jan., 1898..	18·45	,, ..	1 Apr., 1911..	13·60
,, ..	6 Mar., 1898	15·95	,, ..	6 Apr., 1912..	15·55
Eddington (Cloncurry)	23 Jan., 1891	10·33	Granada (late Donaldson)	27 Jan., 1891	11·29
Emu Park ..	31 Jan., 1893	10·00	,, ,,	8 Jan., 1911..	13·50
Enoggera Railway	14 Mar., 1908	12·14	,, ..	9 Jan., 1911..	14·30
Enoggera Reservoir	,, ,,	10·98	Gympie ..	9 Mar., 1901	11·64
Ernest Junction ..	,, ,,	13·00	Halifax ..	5 Feb., 1899..	15·37
Esk	21 Jan., 1887	10·70	,, ...	8 Mar., 1899	11·00
,, ...	14 Mar., 1908	11·12	,, ..	6 Jan., 1901..	15·68
Fassifern ..	21 Jan., 1887	10·20	,, ..	8 Feb., 1901..	10·50
Flat Top Island ..	22 Dec., 1909	12·96	,, ..	26 Mar., 1903	10·07
Floraville ..	6 Jan., 1897..	10·79	,, .	30 Jan., 1906	10·41
,, ..	11 Mar., 1903	12·86	,, .	8 Apr., 1912..	12·75
Flying Fish Point	7 Apr., 1912..	16·06	Hambledon Mill .	7 Jan., 1908..	11·00
Geraldton (now Innisfail)	11 Feb., 1889	17·13	,, ,, ..	13 Jan., 1909	13·80
			,, ,, .	16 Feb., 1910	11·45
,, ..	31 Dec., 1889	12·45	,, ,, .	2 Jan., 1911..	18·61
,, ..	25 Jan., 1892	11·10	,, ..	10 Feb., 1911	13·97
,, ..	6 Apr., 1894..	16·02	,, ,, ..	30 Mar., 1911	13·04
,, ..	3 Mar., 1896	11·42	,, ,, ..	31 Mar., 1911	14·95
,, ..	7 Mar., 1899	10·25	,, ,, ..	1 Apr., 1911..	19·62
,, ..	18 Apr., 1899	13·20	Harvey Creek ..	8 Mar., 1899	17·72
,, ..	24 Jan., 1900	15·22	,, ,, ..	25 Jan., 1900	12·53
,, ..	6 Jan., 1901..	11·35	,, ,, .	25 May, 1901	14·00
,, ..	29 Dec., 1903	21·22	,, ,, ..	14 Mar., 1903	12·10
,, ..	17 Mar., 1904	10·35	,, ,, .	21 Apr., 1903	10·10
,, ..	30 Jan., 1908	11·76	,, ,, ..	11 Jan., 1905	16·96
,, ..	14 Jan., 1909	11·65	,, ,, ..	28 Jan., 1906	12·29
,, ..	11 Feb., 1911	14·48	,, ,, .	20 Jan., 1907	10·13
,, ..	1 Apr., 1911..	12·35	,, ,, .	8 Jan., 1908..	10·31
,, ..	2 Apr., 1911..	15·00	,, ,, ..	30 Jan., 1908	11·31
,, ..	3 Apr., 1911..	11·25	,, ,, ..	25 Mar., 1908	11·84
,, ..	7 Apr., 1912..	20·50	,, ,, ..	14 Jan., 1909	14·40
,, ..	8 Apr., 1912..	12·15	,, ,, ..	16 Feb., 1910	10·90
Gin Gin.. ..	16 Jan., 1905	13·61	,, ,, ..	3 Jan., 1911..	27·75
Gladstone ..	18 Feb., 1888	12·37	,, ,, ..	11 Feb., 1911	12·88
,, ..	31 Jan., 1893	14·62	,, ,, ..	31 Mar., 1911	10·93
,,	4 Feb., 1911.	18·83	,, ,, ..	1 Apr., 1911..	13·61
Glass Mountains ..	26 Dec., 1909	10·48	,, ,, .	2 Apr., 1911..	16·46
Glen Broughton ..	5 Apr., 1894..	18·50	,, ,, ..	17 Mar., 1912	10·15
Glen Prairie ..	18 Apr., 1904	12·18	Haughton Valley	26 Jan., 1896	18·10
Gold Creek Reservoir	16 Feb., 1893	11·16	Hillcrest (Mooloolah)	26 Dec., 1909	13·35
,, ,,	14 Mar., 1908	12·50	Holmwood (Woodford)	2 Feb., 1893..	16·19
Goodna ..	21 Jan., 1887	11·00			
,, ..	14 Mar., 1908	11·03	,, ..	10 Jan., 1898	12·40

HEAVY RAINFALLS, QUEENSLAND—*continued*

Name of Town or Locality.	Date.	Amount.	Name of Town or Locality.	Date.	Amount.
		inches			inches
Homebush ..	3 Feb., 1898..	12·04	Lytton	16 Feb., 1893	11·74
" ..	21 Mar., 1898	10·26	"	20 Mar., 1898	10·20
" ..	11 Jan., 1901	11·40	Mackay	17 Feb., 1888	10·10
Howard ..	15 Jan., 1905	19·55	" ..	15 Feb., 1893	10·46
Indooroopilly ..	14 Mar., 1908	10·28	" ..	3 Feb., 1898..	11·95
Ingham ..	18 Jan., 1894	12·60	" ..	5 Jan., 1904.	10·45
" ..	7 Apr., 1894..	10·10	" ..	23 Dec., 1909	13·96
" ..	6 Jan., 1901..	13·59	" ..	12 Mar., 1910	10·31
" ..	25 Dec., 1903	12·30	Sugar Experimental Farm, Mackay	23 Dec., 1909	12·00
Inkerman ..	21 Sept., 1890	12·93			
Inneshowen (Johnstone River)	30 Dec., 1889	14·01			
			Macnade Mill (Townsville)	28 Mar., 1891	10·61
Innisfail ..	7 Apr. 1912	20·50			
" ..	8 Apr., 1912 .	12·15	" ..	15 Mar., 1893	10·50
Inskip Point ..	13 Mar., 1892	10·65	" ..	18 Jan., 1894	12·56
Isis Junction ..	6 Mar., 1898	13·60	" ..	17 Apr., 1894	14·26
Kamerunga (Cairns)	20 Jan., 1892	13·61	" ..	5 Feb., 1899..	15·20
			" ..	6 Jan., 1901..	23·33
" ..	23 Feb., 1894	10·10	Maleny	14 Mar., 1908	10·95
" ..	6 Apr., 1894..	14·04	"	26 Dec., 1909	14·76
" ..	5 Apr., 1895..	12·31	Manly ..	14 Mar., 1908	11·90
" ..	5 Mar., 1896	11·81	Mapleton ..	14 Mar., 1908	14·29
" ..	8 Mar., 1899	10·50	" .	26 Dec., 1909	15·72
" ..	21 Apr., 1903	11·75	" .	4 Feb., 1911..	10·07
" ..	2 Jan., 1911..	10·95	Mareeba ..	31 Mar., 1911	10·59
" ..	3 Jan., 1911..	10·25	Marlborough ..	17 Feb., 1888	14·24
" ..	11 Feb., 1911	13·07	" ..	29 Jan., 1896	10·84
" ..	17 Mar., 1911	10·30	Mayne Junction ..	14 Mar., 1908	10·30
" ..	1 Apr., 1911..	14·20	Mein .. .	4 Apr., 1895..	10·50
" ..	2 Apr., 1911..	21·00	Milton ..	14 Mar., 1908	12·24
Kilkivan Junction	10 Jan., 1898	11·08	Miriam	12 Jan., 1901	16·59
Kululu, Mackay .	11 Jan., 1901	11·70	"	28 Mar., 1903	10·16
" " ..	12 Jan., 1905	10·94	Molloy . ..	16 Mar., 1911	11·50
Kuranda ..	6 Mar., 1899	14·12	"	30 Mar., 1911	10·00
" ..	20 Apr., 1903	14·16	" . ..	31 Mar., 1911	20·00
" ..	14 Jan., 1909	12·37	"	1 Apr., 1911..	20·00
" ..	27 Jan., 1910	9·40	"	2 Apr., 1911.	20·00
" ..	28 Jan., 1910	9·28	Monkira ..	1 Feb., 1906..	11·61
" ..	3 Jan., 1911..	10·72	Mooloolah ..	13 Mar., 1892	21·53
" ..	11 Feb., 1911	16·30	" ..	2 Feb., 1893..	19·11
" ..	17 Mar., 1911	15·10	" ..	9 June, 1893	11·50
"	31 Mar., 1911	18·60	" ..	6 Mar., 1898	14·43
" ..	1 Apr., 1911..	24·30	Morningside .	14 Mar., 1908	10·50
" ..	2 Apr., 1911..	28·80	Mount Crosby ..	14 Mar., 1908	14·00
Lake Nash ..	10 Jan., 1895	10·25	Mount Cuthbert .	18 Jan., 1911	18·00
" ..	20 Mar., 1901	10·02	Mount Gravatt ..	14 Mar., 1908	10·80
Landsborough ..	2 Feb., 1893..	15·15	Mount Perry	24 Feb., 1887	10·00
" ..	9 June, 1893	12·80	Mourilyan ..	14 Jan., 1909	13·00
" ..	9 Jan., 1898..	9·54	" ..	3 Jan., 1911..	12·70
"	7 Mar., 1898	10·35	" ..	11 Feb., 1911	17·40
" ..	26 Dec., 1909	14·00	" .	1 Apr., 1911	13·20
Low Island ..	10 Mar., 1904	15·07	" .	2 Mar., 1911.	10·59
" ..	16 Mar., 1911	10·15	" ..	7 Apr., 1912..	18·97
" ..	31 Mar., 1911	14·70	Mundoolun	21 Jan., 1887	17·95
" ..	1 Apr., 1911..	15·30	Mungar Junction	10 Mar., 1901	10·20
Lucinda ..	4 Feb., 1899..	11·10	Murrarie .	14 Mar., 1908	11·50
" ..	17 Feb., 1906	13·35	Musgrave ..	6 Apr., 1894..	13·71
" .	10 Mar., 1906	14·60	Nambour .	9 Jan., 1898.	21·00
Lytton	21 Jan., 1887	12·85	" ..	7 Mar., 1898	13·28
"	13 Mar. 1892	10·60	" ..	27 Dec., 1909	16·80

HEAVY RAINFALLS, QUEENSLAND—*continued.*

Name of Town or Locality	Date.	Amount.
		inches
Nanango ..	9 June, 1893	10·00
Nerango ..	15 June, 1892	12·35
,, ..	14 Mar., 1908	10·95
Netley (Rockhampton)	29 Jan., 1895	11·77
Normanton ..	14 Jan., 1905	10·72
North Pine ..	11 Jan., 1887	11·60
,, ..	16 Feb., 1893	14·97
Nundah.. ..	14 Mar., 1908	12·00
One Mile, Gympie	10 Mar., 1901	11·40
Oxenford ..	14 Mar., 1908	15·65
Palmwoods ..	4 Feb., 1893..	12·30
,, ..	10 Jan., 1898	15·85
,, ..	7 Mar., 1898	13·02
,, ..	25 Dec., 1909	17·75
,, ..	3 Mar., 1912	10·00
Peachester ..	26 Dec., 1909	14·91
Pinkenba ..	14 Mar., 1908	11·63
Pittsworth ..	11 Mar., 1890	14·68
Port Douglas ..	15 Mar., 1887	13·00
,, ..	12 Feb., 1888	10·00
,, ..	20 Jan., 1892	11·50
,, ..	23 Feb., 1894	10·25
,, ..	7 Apr., 1894	10·09
,, ..	10 Mar., 1904	16·34
,, ..	29 Dec., 1904	10·67
,, ..	11 Jan., 1905	14·68
,, ..	2 Jan., 1911..	11·64
,, ..	11 Feb., 1911	11·88
,, ..	7 Mar., 1911	16·10
,, ..	1 April, 1911	31·53
Ravenswood ..	24 Mar., 1890	17·00
,, ..	27 Jan., 1896	10·52
Redcliffe ..	21 Jan., 1887	14·00
,, ..	16 Feb., 1893	17·35
,, ..	10 Jan., 1898	10·25
Riverview ..	14 Mar., 1908	10·12
Rockhampton ..	17 Feb., 1888	10·82
,, ..	29 Jan., 1896	10·53
Rosedale ..	6 Mar., 1898	12·60
Sandgate ..	21 Jan., 1887	10·50
,, ..	16 Feb., 1893	14·03
Sherwood ..	14 Mar., 1908	11·08
Somerset ..	28 Jan., 1903	12·02
Southport ..	14 Mar., 1908	11·05
St. Helena ..	16 Feb., 1893	11·20
St. Helens (Mackay)	24 Feb., 1888	12·00
,, ,,	22 Mar., 1898	10·00
St. Lawrence ..	17 Feb., 1888	12·10
,, ..	30 Jan., 1896	15·00
Sunnybank ..	14 Mar., 1908	11·40
		inches.
Tabragalba ..	21 Jan., 1887	10·00
Tallebudgera ..	14 Mar., 1908	10·80
Tambourine Mountain	17 July, 1889	10·91
Taringa ..	14 Mar., 1908	11·40
Tewantin ..	10 Jan., 1898	10·51
,, ..	30 Mar., 1904	12·30
,, ..	14 Apr., 1904	11·36
The Hollow (Mackay)	23 Feb., 1888	15·12
,, ..	— Mar., 1891	10·39
Thornborough ..	20 Apr., 1903	18·07
Tierawoomba ..	2 Feb., 1898..	10·36
Tooloombah ..	29 Jan., 1896	11·70
Toowong ..	14 Mar., 1908	11·60
Townsville ..	24 Jan., 1892	19·20
,, ..	28 Dec., 1903	15·00
Victoria Mill ..	6 Jan., 1901..	16·67
Walkerston ..	12 Jan., 1905	10·60
Walsh River ..	12 Jan., 1903	10·22
,, ..	1 Apr., 1911..	13·70
Woodford ..	2 Feb., 1893..	14·93
,, .	10 Jan., 1898	11·40
Woodlands (Yeppoon)	10 Jan., 1889	10·00
,, ..	26 Jan., 1890	10·22
,, ..	25 Mar., 1890	14·25
,, ..	31 Jan., 1893	23·07
,, ..	30 Jan., 1896	11·91
,, ..	9 Feb., 1896..	13·97
,, ..	7 Jan., 1898..	14·50
Woodstock ..	4 Nov., 1903	10·44
Woogaroo ..	14 Mar., 1908	11·20
Woombye ..	26 Dec., 1909	13·42
Wynnum ..	14 Mar., 1908	11·95
Yandina ..	1 Feb., 1893..	20·08
,, ..	9 June, 1893	12·70
,, ..	9 Jan., 1898..	19·25
,, ..	7 Mar., 1898	13·52
,, ..	28 Dec., 1909	15·80
Yarrabah ..	14 Jan., 1909	11·20
,, ..	3 Jan., 1911..	11·50
,, ..	11 Feb., 1911	12·00
,, ..	2 Apr., 1911	30·65
Yeppoon ..	31 Jan., 1893	20·05
,, ..	30 Jan., 1896	11·02
,, ..	8 Jan., 1898..	18·05
,, ..	8 Apr., 1904..	10·70
,, ..	3 Feb., 1906..	14·90
,, ..	3 Feb., 1911..	14·92
Zillmere ..	14 Mar., 1908	11·00

HEAVY RAINFALLS, NEW SOUTH WALES.

Name of Town or Locality.	Date.	Amount.	Name of Town or Locality.	Date.	Amount.
		inches			inches
Albion Park	8 Feb., 1895	10·00	Leconfield	9 Mar., 1893	14·53
Albury	14 Feb., 1898	10·70	Liverpool	23 Feb., 1874	10·39
Alne Dorrigo	22 Jan., 1893	10·27	Macksville*	23 Feb., 1908	10·00
Anthony	28 Mar., 1887	17·14	Madden's Creek	2 Feb., 1908	10·36
"	15 Jan., 1890	13·13	"	13 Jan., 1911	18·08
Arnold Grove	28 May, 1889	11·13	Maitland West	9 Mar., 1893	14·79
"	20 Mar., 1892	10·08	Major's Creek	14 Feb., 1898	12·32
Araluen	14 Feb., 1898	10·51	Marrickville	9 Mar., 1913	10·40
"	15 Feb., 1898	13·36	Milton	13 Jan., 1911	10·41
Bellawongarah	13 Jan., 1911	10·92	Mittagong	6 Mar., 1893	11·71
Berry	" "	12·05	Morpeth	9 Mar., 1893	21·52
Billambil	14 Mar., 1894	12·94	Mount Kembla	14 Feb., 1898	10·25
Bomaderry	13 Jan., 1911	13·03	"	2 Feb., 1908	10·27
Bowral	6 Mar., 1893	11·94	"	13 Jan., 1911	18·25
Bowraville	22 June, 1898	11·50	Mount Pleasant	14 Jan., 1911	10·40
Broger's Creek	14 Feb., 1898	20·05	Myra Vale	14 Feb., 1898	10·00
"	19 July, 1910	12·22	Nambucca Heads	3 Apr., 1905	10·62
Broger's Creek Upper	13 Jan., 1911	20·83	Nepean Tunnel	14 Feb., 1898	12·30
			Nethercote	14 Jan., 1911	11·32
Bulli Mountain	19 Mar., 1894	10·45	Newcastle	19 Mar., 1871	11·17
"	13 Feb., 1898	17·14	"	9 Mar., 1893	11·14
Burwood	28 May, 1889	11·75	"	24 Feb., 1908	10·02
Camden	11 July, 1904	10·90	Nowra	11 July, 1904	11·50
Camden Haven	22 Jan., 1895	12·23	Nowra T.O.	13 Jan., 1911	13·00
Canley Vale	28 May, 1889	10·06	Padstow Park	9 Mar., 1913	10·64
"	20 Mar., 1892	10·85	Parramatta	28 May, 1889	11·94
Castle Hill	28 May, 1889	13·49	"	20 Mar., 1892	11·01
Cockle Creek	23 Feb., 1908	10·45	Port Macquarie	9 Nov., 1887	10·76
Colombo Lyttleton	5 Mar., 1893	12·17	Port Stephens	9 Feb., 1889	10·15
Condong	27 Mar., 1887	18·66	Prospect	28 May, 1889	12·37
"	15 Jan., 1890	11·50	Raymond Terrace	28 Sept., 1903	10·32
Cookville	1 Apr., 1892	11·31	Richmond	28 May, 1889	12·18
Coramba	11 June, 1893	10·83	Robertson	14 Feb., 1898	10·00
Cordeaux River	26 Feb., 1873	10·98	"	10 July, 1904	10·50
" "	3 Feb., 1890	11·51	Robertson P.O.	13 Jan., 1911	10·28
" "	14 Feb., 1898	22·58	Rooty Hill	27 May, 1889	11·85
" "	31 Aug., 1906	10·31	Rylstone	28 May, 1889	10·26
" "	13 Jan., 1911	14·52	Seven Oaks	22 June, 1898	11·06
Cudgen	15 Mar., 1894	10·23	South Head (near Sydney)	29 Apr., 1841	20·12
Dapto West	14 Feb., 1898	12·05			
"	13 Jan., 1911	10·37	" "	16 Oct., 1844	20·41
Darkes' Forest	8 Feb., 1895	11·10	Springwood	7 Mar., 1894	10·55
Dunheved	28 May, 1889	12·40	Stockyard Mount	13 Jan., 1911	11·54
Eden	4 May, 1875	10·52	Taree	28 Feb., 1892	12·24
Fernmount	2 Feb., 1890	10·36	Terara	26 Feb., 1873	12·57
"	2 June, 1903	11·29	Tomago	9 Mar., 1893	13·76
Goorangoola	9 Mar., 1893	10·34	Tongarra	9 July, 1904	11·10
Guy Fawkes	2 June, 1903	11·30	Tongarra Farm	14 Feb., 1898	15·12
Helensburgh	13 Jan., 1911	12·20	Towamba	5 Mar., 1893	20·00
Hercynia	28 May, 1889	11·85	Tweed Heads	14 Jan., 1890	10·53
Holy Flat	12 Mar., 1887	12·00	"	14 Mar. 1894	11·40
"	28 Feb., 1892	12·24	Trial Bay	9 Mar., 1893	11·13
Jamberoo	14 Feb., 1898	10·92	White Swamp	12 Jan., 1911	10·24
"	13 Feb., 1911	10·89	Wollongong	26 Feb., 1873	11·00
Kareela	20 Oct., 1902	11·73	"	5 Apr., 1882	10·00
Katoomba	7 Apr., 1913	10·50	Woolgoolga	11 June, 1893	10·83
Kembla Heights	13 Jan., 1911	17·46	Yellow Rock	14 Feb., 1898	11·69
Kempsey	10 Mar., 1893	10·34			

* 6·50 inches fell in 2 hours.

Table of Mean Monthly and Annual Rainfalls at Capitals and Principal Towns in the Commonwealth.

City	Latitude	Longitude	Height	Distance from Coast	January	February	March	April	May	June	July	August	September	October	November	December	Year
	S.	E.	Feet.	Miles.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
Port Darwin	12° 28′	130° 51′	97	..	15·27	13·05	9·70	4·50	0·75	0·16	0·07	0·11	0·48	2·12	5·21	10·30	61·72
Broome	17° 57′	122° 15′	34	..	4·96	6·35	3·77	1·35	0·41	1·22	0·27	0·04	0·08	0·03	0·93	3·55	22·96
Perth	31° 57′	115° 51′	197	12	0·33	0·31	0·71	1·65	4·88	6·51	6·44	5·55	3·37	2·06	0·76	0·54	33·11
Kalgoorlie (Coolgardie)	30° 45′	121° 30′	1,261	387	0·33	0·61	0·82	0·69	1·41	1·18	0·92	0·93	0·55	0·79	0·45	0·59	9·27
Alice Springs	23° 38′	133° 37′	1,926	576	1·68	1·73	1·24	0·90	0·60	0·57	0·46	0·40	0·41	0·72	0·90	1·32	10·93
Adelaide	34° 56′	138° 35′	140	6	0·74	0·60	1·07	1·88	2·77	3·09	2·66	2·51	1·94	1·75	1·13	0·94	21·08
Broken Hill	30° 58′	141° 21′	1,001	220	0·79	0·81	0·63	0·75	0·91	1·22	0·65	0·98	0·69	0·84	0·59	0·79	9·65
Bendigo	36° 46′	144° 17′	825	73	1·37	1·04	1·55	1·67	2·12	2·73	2·01	2·21	2·05	2·04	1·52	1·19	21·50
Ballarat	37° 33′	143° 52′	1,430	46	1·70	1·34	2·01	2·46	2·92	3·10	2·59	2·86	2·91	2·76	2·26	1·82	28·76
Geelong	38° 10′	144° 21′	90	1	1·34	1·24	1·63	1·83	1·96	2·03	1·49	1·60	1·89	1·84	1·68	1·19	19·72
Melbourne	37° 50′	144° 59′	115	3	1·85	1·74	2·18	2·32	2·15	2·11	1·86	1·81	2·35	2·64	2·20	2·30	25·51
Hobart	42° 53′	147° 22′	160	1	1·80	1·45	1·65	1·80	1·91	2·22	2·10	1·83	2·14	2·24	2·50	1·93	23·57
Launceston	41° 27′	147° 10′	33	32	1·96	1·10	1·85	2·07	2·54	3·45	2·99	2·77	2·97	2·61	1·81	2·04	28·16
Canberra	35° 20′	149° 15′	1,910	60	2·46	1·78	1·97	1·63	1·69	1·94	1·31	1·53	1·80	2·28	2·20	2·06	22·65
Bulli (Wollongong)	34° 25′	150° 56′	33	..	4·01	4·94	4·11	4·92	3·86	4·59	3·26	2·77	2·77	2·77	2·69	2·90	43·65
Sydney	33° 52′	151° 12′	146	5	3·67	4·70	5·07	5·24	4·95	5·18	4·68	3·29	2·89	2·82	2·91	2·60	48·00
Newcastle	32° 55′	151° 49′	112	1	3·50	4·60	5·46	4·42	4·83	4·17	4·44	3·42	3·26	2·98	2·87	3·23	47·18
Maitland	32° 45′	151° 35′	19	18	3·23	3·64	3·94	2·72	2·45	2·52	2·67	2·42	2·66	2·27	2·42	2·84	33·78
Brisbane	27° 28′	153° 2′	137	10	6·66	6·63	6·20	3·64	2·92	2·62	2·33	2·35	2·05	2·78	3·65	5 12	46·95
Rockhampton	23° 24′	150° 30′	37	18	9·26	8·36	5·43	2·44	1·63	2·03	1·63	1·01	1·38	1·72	2·17	4·04	41·10
Thursday Island	10° 34′	142° 12′	17	..	18·15	17·29	14·36	8·01	1·65	0·47	0·30	0·22	0·10	0·29	1·29	5·76	67·89

Western Australia.

The heaviest rainfall occurs over the south-western portion of the State, which has a long coast-line exposed to the Indian Ocean and the full force of the westerly winds of southern latitudes, and the rainfall there and in fact over the south-western half of the State, except the eastern gold-fields, is a winter one, 80 to 90 per cent. of the annual totals, in the south-western

agricultural areas, falling during the growing period, April to October. From the coast for about 80 to 100 inland miles the rainfall decreases rather rapidly, but the area in the south-west over which 15 or more inches fall amounts to 74,206 square miles.

The rapid decrease from the west coast inland is partly accounted for by the range of hills which runs parallel to the coast from the extreme south to beyond the Murchison River, although they are not of sufficient elevation to serve as a natural store for precipitation in the form of snow. At some places on the southern portions of these hills, the annual rainfall exceeds 42 inches, about 10 more than on the coast. Inland, owing to the vast extent of land between the gold-fields and the South Australian boundary, over which the easterly winds pass, the evaporation is very great, amounting to about 87 inches annually at Coolgardie, while on the coast, at Perth, it is 66 inches.

The full effects of the westerly winds of southern latitudes are apparently not felt beyond lat. 27 degrees, just reached by the 15-in. isohyet, and from there to the tropic the rainfall is scanty and occasionally amounts to only 3 or 4 inches in the year.

From that isohyetal inland, towards the Murchison and North Coolgardie gold-fields, the records only extend back some ten or fifteen years, but it is not likely that longer records will show a much larger annual rainfall. The 10-in. isohyet which skirts Peak Hill and Wiluna is probably doubtful, and may ultimately have to be modified, as the record used in obtaining the average rainfall at these two stations was very largely inflated by the abnormal falls in March and April, 1900, and January and February, 1902, when Peak Hill registered 18·13 and 14·56 respectively, and Wiluna 22·82 and 9·69 inches.

North of the Tropic, the Kimberley district receives good tropical rains during the summer months, from November to March or April, but the De Grey and Fortescue districts are dependent for their rainfall partly on the tropical storms, commencing about December, and partly on the winter rains from the Indian Ocean, but the total amounts are smaller than those in the Kimberley district, and very variable, as sometimes both the tropical and southern winter rains fail, and at other times phenomenal falls occur during the "willy willy" season, *e.g.*, Whim Creek registered 36·53 inches on three days in April in 1898.

The areas in Western Australia receiving varying quantities of rainfall, as shown on the map, are as follows :—

	Area in Square Miles		
	Tropical, North of Tropic	Rest of Western Australia, South of Tropic.	The Whole State
Over 40 inches	..	3,376	..
From 30 to 40 inches	28,940	11,810	..
„ 25 „ 30	36,973	7,127	..
„ 20 „ 25	36,693	14,611	..
„ 15 „ 20	52,640	37,282	..
„ 10 „ 15	153,870	78,945	..
Under 10 inches	..	..	513,653
Total . ..	309,116	153,151	513,653

South Australia.

The main factors which determine the rainfall distribution of South Australia are the proximity of the Southern Ocean and the long extent of coast line exposed to the free and unrestricted sweep of the westerly winds nautically known as the roaring forties; the rainfall over all the coastal areas is essentially a winter one, and practically all available for agricultural purposes, as from 70 to 90 per cent. of the annual totals in the more settled areas, falls during the growing period, April to October.

Though physiographic influence is less apparent than in south-eastern Australia, the effect of elevation is marked by the heavier rainfalls on the eastern sides of Spencer's Gulf and Gulf St. Vincent, and by the northerly extension of the 10-in. isohyetal from Port Augusta to beyond Blinman. The abundant rain on the Mount Lofty ranges to the east of Adelaide are a conspicuous example of this, the annual total on the crest of the range reaching to nearly 47 inches.

A rapid decrease of the rainfall takes place from the agricultural areas northwards to the interior, where, in the Lake Eyre basin, which is below sea-level, the average annual fall—largely made up of capricious summer storms—is under 5 inches, this district being probably the driest part of the continent.

In the Northern Territory the chief factor in the distribution of the rainfall, which is almost entirely confined to the six summer months, is latitude or distance from the north coast—the rains being abundant on the coast, but rapidly decreasing towards the interior.

The areas in South Australia and the Territory enjoying varying quantities of rainfall, as shown on the map, are as follow:—

Rainfall.	Area in Square Miles.	
	South Australia.	Northern Territory.
Over 40 inches	64	46,780
From 30 to 40 inches	984	40,690
" 25 " 30	3,197	47,580
" 20 " 25	10,630	45,890
" 15 " 20	14,190	62,920
" 10 " 15	33,405	141,570
Under 10 inches .. .	317,600	138,190
Total .. .	380,070	523,620

Queensland.

The eastern littoral of Queensland from Cape York to the Tweed receives an annual average rainfall of about 60 inches. On parts of the north coast, between Cooktown and Townsville, this increases to 150 and 165 inches per annum. The main source of supply is the south-east trade wind, and local variations in totals are solely due to differences in elevations of the shore line.

On the Peninsula the rainfall ranges from 69 inches at Cape York to 32 inches at Georgetown; in lower Carpentaria, it averages about 25 inches.

In the central districts the average varies from 30 inches on the eastern boundary to 20 inches on the western.

In the Maranoa it averages about 23 inches, and over the Darling Downs from 25 to 30 inches. In the Warrego, it varies from 15 to 20 inches, and in the far western districts from 15 inches down to 6 inches at Birdsville, in the extreme south-west corner.

During the wettest months of the year, viz., January, February, and March, very heavy daily falls over the eastern areas are not by any means infrequent. A fall of 10 inches and over in the 24 hours has been recorded on many occasions. On 2nd February, 1893, 35·71 inches were measured at Crohamhurst; this constitutes one of the world's records for heavy rainfall. On that occasion the total measurement for the four days ending 3rd February was 77·305 inches, or nearly 6½ feet.

The following table shows the areas in square miles of varying quantities of rainfall :—

Rainfall	Area in Square Miles
Over 80 inches	2,826
From 70 to 80 inches	2,379
" 60 " 70 "	10,261
" 50 " 60 "	18,167
" 40 " 50 "	60,466
" 30 " 40 "	80,556
" 25 " 30 "	100,137
" 20 " 25 "	118,391
" 15 " 20 "	116,790
" 10 " 15 "	97,722
Under 10 inches	62,805
Total	670,500

New South Wales.

Proximity to the ocean, with prevailing winds of favorable direction, is, in all countries, the chief factor accounting for the greatest totals being generally recorded along the coast line. New South Wales shows no exception to this law, but it is noticeable that nearly all the districts near the coastal rivers show a depressed rainfall in comparison with surrounding and naturally higher country.

Starting from the northern border, the 50-in. isohyetal line at Casino, on the Richmond River, deviates slightly towards the sea line; and the same feature may be noted, in a more or less marked degree, on the Clarence, Macleay, Manning, Hunter, and Shoalhaven Rivers; while the Nepean Valley can be traced right through from Picton to the Hawkesbury by its relatively light rainfall.

On the northern tablelands the higher levels enjoy falls well over 30 inches. The extension of that isohyet encloses a narrow tongue-shaped area, reaching in a south-westerly direction from Inverell to Lindsay, owing to the elevation of this area being higher than that of the country on its west and south boundaries.

The series of short ranges, reaching from Murrurundi to the Warrumbungle, can be readily followed by the relatively higher rainfall figures.

Further south, the Blue Mountains are particularly conspicuous, also the Canobolas. The extension of the Australian Alps, which almost entirely feed the Murrumbidgee, and contribute largely to the constant flow of the Murray, stands out in clear relief. Although a considerable distance from the coast, the elevation is such as to modify the disadvantage resulting therefrom; and not only is abundant moisture extracted from the winds from off the east coast, but considerable condensation takes place on the western aspect from the south-west winter winds after they have swept across nearly the whole length and breadth of Victoria.

The comparatively light rainfall in the district extending from Delegate to Yass, and conspicuously so between Bobundra and Michelago, is one of the most remarkable features of the rainfall map of Australia. Although the greater part of this district is considerably over 2,000 feet high, it is enclosed by ranges of mountains rising to 3,000 and 5,000 feet, which condense from all directions moisture that would otherwise benefit it.

It may be added that, although the falls over this area do not exceed 25 inches, yet it is remarkably productive, for the reason that evaporation is relatively small, and that a vast quantity of soakage must find its way there from the encompassing ranges.

The Sydney and Burrinjuck water supply catchment areas receive annual totals ranging from 30 to 60, and from 20 to 60 inches respectively.

The areas in New South Wales, enjoying varying quantities of rainfall, are shown in the following table:—

Rainfall.	Area in Square Miles
Over 70 inches ..	668
From 60 to 70 inches	1,765
" 50 " 60	4,329
" 40 " 50	15,804
" 30 " 40	30,700
" 20 " 30	77,202
" 15 " 20	57,639
" 10 " 15	77,268
Under 10 inches ..	44,997
Total	310,372

Victoria.

A casual glance at the rainfall map of Victoria will again indicate the great control exercised in rainfall distribution over the earth's surface by the mountains and proximity to the seashore. In regard to the latter factor, it will be noticed that the isohyets generally follow the contour of the coast line, and in the former the heaviest records are coincident with the highest mountains of the State.

The abundant rains on the Australian Alps, the Cape Otway ranges, and the Gippsland ranges are particularly conspicuous. In a less striking manner is shown the precipitating effect of the Central Dividing Range and the Grampians. The relatively depressed areas to the north and west of Melbourne suffer in regard to the comparative smallness of their rainfall through the effect of the higher surrounding country on rain-bearing winds. A similar effect is noticeable in the Latrobe, Thomson, Tambo, and Mitta Mitta Valleys.

While contending that the rainfall over the eastern portion of Australia is in no wise short of that experienced in other continents, we must not lose sight of the fact that our mountain chains are not sufficiently high, nor have they the extent of area, to compensate for Australia's deficiency of rainfall in the areas far removed from the coast, *i.e.*, they are not of sufficient elevation to serve as a natural store for precipitation in the form of snow, and also that the loss of moisture by evaporation is abnormal. It is, therefore, imperative, if equalizing results are to be obtained from the capriciousness of our rainfall seasons, that artificial storage in reservoirs at the catchments be resorted to, and all rivers, particularly those inland, dammed and locked as a national policy of paramount importance, and, further, that the waters in rivers, lakes, and reservoirs, be protected from desiccating winds by the liberal planting of trees.

In studying the distribution of rainfall, as depicted on the map, we find that the areas in Victoria enjoying varying quantities of rainfall per annum are as follow :—

Rainfall.	Area in Square Miles.
Over 60 inches ..	1,597
From 50 to 60 inches ..	3,348
" 40 " 50 " ..	7,055
" 30 " 40 " ..	14,029
" 25 " 30 " ..	15,247
" 20 " 25 " ..	14,070
" 15 " 20 " ..	12,626
Under 15 inches ..	19,912
Total ..	87,884

Tasmania.

In the West Coastal district and the north-east, the rainfall varies so very much that until records are available for a long series of years, the isohyets are bound to be considerably altered at the end of each year.

The extremes and means are shown in the following table, viz. :—

—	Highest.	Lowest	Mean
	Inches.	Inches	Inches
North-east district, Springfield ..	86·84	36·81	57·68
Western district—			
Waratah ..	117·24	59·97	85·52
Mount Read ..	145·04	70·38	110·45

The most striking feature in these parts of the island is the great variation shown for such a comparatively small area between the greatest and least average falls, viz., from 17·93 inches at Beaufront (Ross), to 115·82 at Mount Lyell on the West Coast, showing a range of 97·89 inches. This accentuates the great control exercised upon the rainfall by the physiographic conditions and proximity to the seashore.

The West Coast, being exposed to the full sweep of the moisture-laden westerly winds, and condensation being assisted by altitudes of between

3,000 and 5,000 feet, experiences frequent rains, and, as may be seen by a glance at the map, high annual averages, over 100 inches in places, are the result.

The effect of altitude is again noticeable in the south-east, where Hobart, at an elevation of 160 feet, has an annual rainfall of 23·57 inches, while Mount Wellington, at the 2,500-ft. level, totals 60·34 inches.

The heavy rains experienced in the north-east are similar in character to those on the coast of New South Wales and eastern Victoria, and the south-east winds exercise a certain amount of control over the rainfall of this portion of the island.

The areas in Tasmania enjoying varying quantities of rainfall, as shown on the map, are as follow :—

Rainfall.	Area in Square Miles.
Over 100 inches	553
From 80 to 100 inches	1,235
" 60 " 80 "	2,097
" 50 " 60 "	2,767
" 40 " 50 "	3,449
" 30 " 40 "	4,588
" 20 " 30 " Mainland	6,035
" 20 " 30 " King, Flinders, and other Islands ..	1,524
Under 20 inches	937
Total	23,185
No records available—	
In south-west of Mainland	2,927
On Islands of North-west Group ..	103
Grand Total Area	26,215

Bruni Island has been included with the Mainland.

8. Rainfall During the Wheat-growing Period.

In Australia wheat-growing under ordinary conditions is generally considered a safe and payable proposition when 10 inches of rain and over falls from the month of April to that of October inclusive.

The accompanying map (Fig. 9) has been compiled for the purpose of showing what portions of the continent are favoured with the above requirements.

There are in all 484,330 square miles of country with 10 inches of rainfall and over during the wheat-growing period, distributed as follows :—93,500 square miles in Western Australia, 46,980 square miles in South Australia, 79,247 square miles in Queensland, 163,772 square miles in New South Wales, 74,616 square miles in Victoria, and 26,215 square miles in Tasmania.

Much of these areas, however, is unsuitable, probably half the total, by reason of excessive rains, early summer rain, topography and soil, but as compensation there are vast tracts of interior land possible for cereal growth by the adoption of drought resisting seed and dry farming methods, which, in all probability, may still give the estimated 500,000 square miles or even more for wheat cultivation.

During the year 1912–13 there were only 11,247 square miles, less than half the area of Tasmania, under wheat, yielding 88,554,738 bushels. This is approximately only one-third of the area at present used for this purpose, allowing for land under fallow and rotation of crops. Estimating, therefore, that only a third of the 500,000 would be available each year for wheat cultivation, the possible output from Australia could reach 900 to 1,000 million bushels.

From the trend of developments during the last few years it would appear that the greatest scope for expansion in wheat production is in New South Wales and Western Australia.

The boundary of the 10-in. wheat period isohyet starts on the west coast of Western Australia, a few miles to the south of Hamelin Pool, thence passes inland in a south-easterly direction towards Southern Cross, from there almost due east, entering the Great Bight to the north of Israelite Bay. It again enters the mainland between Fowler's Bay and Streaky Bay, in South Australia, curving south-eastwards from Yardea to Spencer's Gulf to the north of Cowell, and crossing the Gulf it strikes the Peninsula near Port Pirie, forming a loop over the country well to the north of Port Augusta, whence it takes a sinuous course southwards through the lower Mallee to the north-east Wimmera, crossing the Murray in a north-easterly direction to the west of Deniliquin in Riverina, then over the Murrumbidgee at Darlington Point, from there bending northwards and passing successively near Mount Hope, Nymagee, Coonamble, Walgett, to Mungindi, whence it extends almost in a direct line northwards, finally leaving the Queensland coast at Bowen.

It will be noticed how remarkably closely the 10-in. and Goyder's line follow one another in South Australia.

In New South Wales, however, there are considerable deviations between Coghlan's and the 10-in. wheat lines.

Goyder's line was determined in 1865 by Mr. G. W. Goyder, the Surveyor-General of the then colony, based upon the estimated average rainfall and native flora.

Coghlan's line was determined by Mr. T. Coghlan, State Statistician, in 1903, based upon rainfall data and the actual experience of growers.

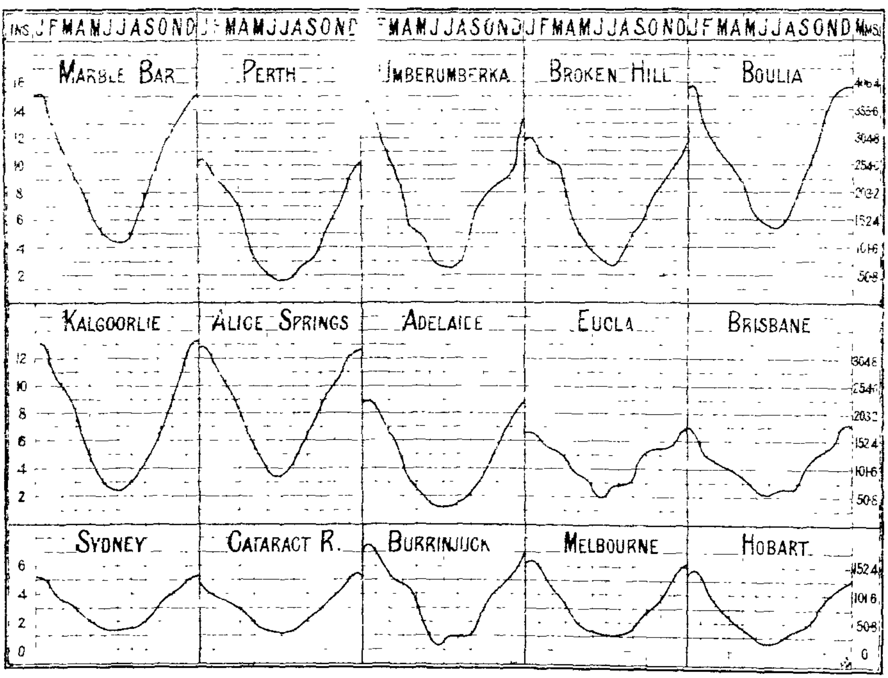
The percentage lines of the wheat-growing period in relation to the annual average rainfall are of considerable interest, and emphasize the alternating distinct wet and dry season in Australia already referred to.

Roughly speaking, from 60 to 70 per cent. of the annual total precipitation falls over southern Australia during the seven coldest months, and from 30 to 40 per cent. during the hottest months. North of the tropic the quantitative distribution is reversed, only 10 to 40 per cent. falling during the cold months and from 60 to 90 per cent. during the hot months.

In the south-western portion of Western Australia, it will be observed that 90 per cent. of the annual average rainfall is precipitated in the winter and 10 per cent. only during the summer months.

On the south-eastern shores of the Gulf of Carpentaria we have the other extreme—only 5 per cent. of the year's rainfall total falls within the seven cold months mentioned, and 95 per cent. during the remaining five.

Graph showing Mean Monthly Evaporation at Selected Stations.



NOTE.—Each vertical space represents 1 inch or 25·4 millimetres.

FIG. 12.

9. Snow.

Perennial snow occurs only over the sheltered crevices in the highest portions of the Australian Alps, where, however, during the winter months it accumulates to a depth of many feet, and by gradual thawing maintains a constant flow of water to the Murray and Snowy Rivers throughout the year.

During the winter period snow can always be expected along the mountain ranges in New South Wales, Victoria, and Tasmania, and occasionally on the Mount Lofty ranges, in South Australia. On rare occasions also it has reached as far north as Toowoomba, in Queensland, latitude 27° 28′ S.

Over the plain country it has been known to fall as far west as Louth, on the Darling River, over the whole of eastern and southern Victoria, except the immediate coast line. In South Australia it has been recorded over a belt of country lying to the east of Spencer's Gulf, about 200 miles long, running from north to south and 75 miles wide. It has only been noted at one place to the west of the Gulf, viz., at Yardea, near Lake Gardner.

In Western Australia it has been recorded on the hills in the extreme south-west, and at a few places on the southern gold-fields.

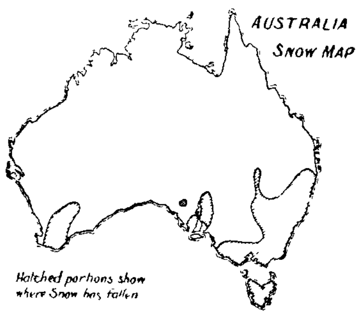


FIG. 10.

The heaviest snowstorm on record in New South Wales occurred between 3rd and 7th July, 1900, extending from Congewar in the Hunter district to Condobolin and Warrumbungle, in the west. Railway traffic became paralyzed, passengers being shut up in carriages and unable to reach hotels. In places the snow was 8 feet deep on the rails. At Bathurst, many roofs, verandahs, etc., collapsed under its weight, while telegraph lines were levelled everywhere.

In 1901, on 28th July, the most widespread snowstorm occurred over south-eastern Australia, being practically general east of the 145th meridian. Another remarkable storm on the 29th and 30th August, 1905, extended from South Australia through southern Victoria along the highlands of New South Wales to within 30 miles of the Queensland border.

On the mainland Sydney and Melbourne are the only two capital cities that possess authenticated records of appreciable snow falls. In Sydney on June 30th, 1836, snow fell for half-an-hour, sufficient being on the ground to enable boys to make snowballs

Melbourne was covered with snow 7 to 12 inches deep on the morning of the 31st August, 1849. Another remarkable fall took place on the 7th August, 1899, between 1 and 2 p.m., when snow fell heavily in the Fitzroy Gardens, and snowballing was indulged in at the Scotch College. A light to heavy fall also occurred over the north-eastern suburbs of Melbourne between 7 and 8 a.m. on the 25th September, 1905. Flakes of snow were observed in, or close to, Melbourne on 14th July, 1840, 27th June, 1845, 26th July, 1882, 28th June, 1900, 18th April, 1910, and 21st June, 1911.

10. Evaporation.

The problems which inevitably face the engineering work of water conservation for the development and expansion of Australia's as yet unused territory demand that the fullest knowledge possible respecting the rate and distribution of evaporation (a climatic element second in importance to rainfall only) should be available.

For the purpose of obtaining data on this subject a number of iron jacketed tanks 3 feet in diameter have been distributed to several selected centres.

The tops of the tanks are sunk to within an inch of the surface level of the ground. They contain about 130 gallons of water, which is replenished when or before a fall of 6 inches from the top of the tank takes place, in order that the exposed level may be fairly constant and also that the added water may not materially affect the temperature of the main body.

Information collected up to the present is not very extensive, nor do the observations in some cases extend over many years, but sufficient has been obtained to approximate roughly the times of equal evaporation and the aggregate annual amounts in different parts of the continent.

The results deduced from observations carried out at the capital cities over a great number of years establish the rate and total evaporation taking place over coastal regions south of the tropic. At coastal stations north of the tropic, viz., Rockhampton, Cooktown, Thursday Island, Port Darwin, the annual totals have been computed with Fitgzerald's formula :—

$$E = [\cdot 014 (V - v) + \cdot 0012 (V - v)^2] [1 + \cdot 67w^{\frac{1}{2}}].$$

Marble Bar, Alice Springs, Boulia, and Broken Hill furnish results for the interior. Those at Broken Hill were undertaken at the Stephen's Creek Reservoir by Mr. Whitehead, the engineer of the silver city, and give the actual loss of water from the extensive artificial lake. It is satisfactory to note that the record from the standard tank at the Umberumberka site but a few miles away gives only a difference of 3 399 inches for the twelve months.

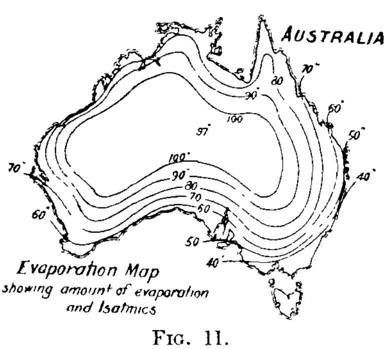


FIG. 11.

It will be seen by reference to the accompanying table and chart that about a third of the continent, almost coincident with that portion having but an average annual rainfall of 10 inches and under, loses from exposed water 100 inches and over per annum.

The daily rate of evaporation during the summer months is considerable, more especially inland, where from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch daily is a common occurrence, and at times up to an inch and over, hence, if it is desired to receive any benefit from showers, any possible means that can be adopted to break the surface soil, and so let the rain through, must be resorted to, even on grazing land.

TABLE OF MEAN MONTHLY AND ANNUAL EVAPORATION AT STATIONS IN THE COMMONWEALTH.

Station	Latitude	Longitude	Distance from Coast.	Number of Years	January	February.	March.	April	May.	June	July.	August	September	October.	November	December.	Year.
	S.	E.	Miles.		Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
Marble Bar.. ..	21° 11′	119° 42′	75	..	15·109	12·918	10·355	8·337	5·922	4·682	4·383	6·113	8·650	11·303	13·033	14·533	115·338*
Perth	31° 57′	115° 51′	12	14	10·39	8·76	7·67	4·84	2·65	1·69	1·63	2·35	3·30	5·27	7·72	9·86	66·13
Kalgoorlie (Coolgardie)	30° 45′	121° 30′	387	2	13·09	10·62	9·29	6·18	3·78	2·48	2·48	3·55	5·33	7·49	10·35	13·10	87·74
Alice Springs .	23° 38′	133° 37′	576	20	12·729	10·875	9·538	6·863	4·868	3·391	3·659	5·135	7·296	9·558	10·939	12·252	97·103
Boulia	22° 55′	139° 38′	356	1	15·692	12·243	10·691	9·439	6·877	5·806	5·416	6·670	9·311	11·735	15·044	15·589	124·513*
Adelaide	34° 56′	138° 35′	6	42	8·965	7·297	5·773	3·399	1·980	1·224	1·289	1·846	2·822	4·732	6·565	8·395	54·287
Umberumberka ..	31° 47′	141° 13′	210	1	14·718	12·023	9·400	5·562	1·775	2·760	2·587	3·390	6·721	8·126	8·897	11·559	90·518
Broken Hill ..	30° 58′	141° 21′	220	4	11·918	10·325	9·836	6·331	4·026	3·325	2·739	4·184	5·364	7·781	9·069	10·738	85·636
Melbourne	37° 50′	144° 59′	3	40	6·343	5·007	3·877	2·350	1·463	1·100	1·046	1·470	2·253	3·273	4·500	5·700	38·382
Hobart ..	42° 53′	147° 22′	1	3	5·738	4·176	2·880	1·991	1·211	0·644	0·783	1·280	1·734	2·904	4·176	4·861	32·378
Burrinjuck ..	34° 59′	148° 36′	118	1	7·565	6·192	4·930	4·333	1·961	0·359	0·995	0·943	2·053	3·821	4·791	5·855	43·798
Cataract River ..	34° 15′	150° 46′	12	6	5·260	3·701	3·207	2·539	1·579	1·260	1·196	1·678	2·479	3·443	4·201	5·497	36·040
Sydney	33° 52′	151° 12′	5	33	5·101	3·960	3·350	2·453	1·629	1·360	1·413	1·718	2·560	3·710	4·404	5·258	36·916
Brisbane	27° 28′	153° 2′	10	3	6·492	4·846	4·352	3·826	2·952	2·192	2·422	2·479	3·900	4·989	5·720	7·089	51·259
Rockhampton ..	23° 24′	150° 30′	18	..	..	..	..	..	..	..	..	..	..	..	..	..	58·†
Cooktown	15° 28′	145° 17′	..	..	..	..	..	..	..	..	..	..	..	..	..	..	54·†
Thursday Island ..	10° 34′	142° 12′	..	..	..	..	..	..	..	..	..	..	..	..	..	..	77·†

* Some amounts estimated.
† Estimated.

11. Barometric Pressure.

South of a line joining Perth and Rockhampton the annual average pressure is 30 inches. To the north of that line it gradually diminishes to 29·80 near Cambridge Gulf, on the extreme north-west coast.

In January the average pressure over Southern Australia varies from 29·85 to 29·90, and in Northern Australia from 29·70 to 29·80 inches.

In July south from the tropic the average is from 30·10 to 30·15, and north of it from 30·10 to 29·90.

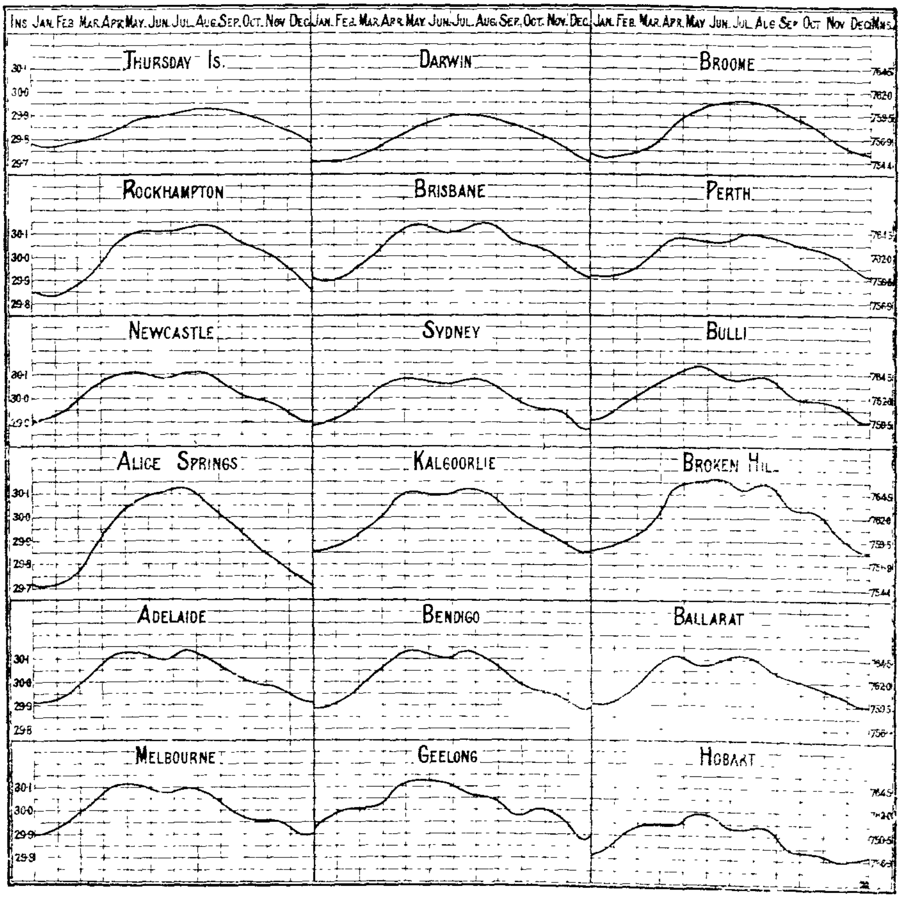
Over the northern half of the continent only one monthly maximum and minimum of pressure is noticeable, viz., in July and January respectively, but over the southern half there are two minima which become increasingly marked as the south-east corner of the continent is approached. These minima occur in May and July.

Throughout the year there is generally shown a concentration of pressure over the south-eastern quarter of the continent and the reverse in the north-western quarter.

TABLE OF MEAN MONTHLY AND ANNUAL BAROMETRIC READINGS, REDUCED TO 32° F., M.S.L., AND STANDARD GRAVITY AT CAPITALS AND PRINCIPAL TOWNS IN THE COMMONWEALTH.

—	Height above sea-level	January.	February	March	April.	May.	June.	July	August	September.	October.	November.	December.	Year
	Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches
Port Darwin	99	29·699	29·708	29·745	29·793	29·849	29·878	29·896	29·890	29·863	29·826	29·780	29·725	29·804
Broome ..	34	29·721	29·731	29·758	29·847	29·920	29·950	29·962	29·951	29·908	29·860	29·792	29·718	29·846
Perth ..	197	29·911	29·927	29·990	30·074	30·079	30·065	30·096	30·088	30·057	30·034	29·991	29·932	30·021
Kalgoorlie ..	1,261	29·866	29·900	29·968	30·069	30·106	30·092	30·118	30·101	30·026	29·968	29·912	29·858	29·999
Alice Springs	1,926	29·707	29·734	29·849	29·983	30·071	30·103	30·127	30·058	29·976	29·887	29·804	29·741	29·920
Adelaide ..	140	29·914	29·951	30·039	30·116	30·123	30·098	30·133	30·100	30·042	29·997	29·974	29·919	30·034
Broken Hill	1,001	29·875	29·905	29·962	30·120	30·154	30·163	30·114	30·112	30·042	30·030	29·934	29·860	30·025
Bendigo ..	825	29·890	29·936	30·025	30·104	30·132	30·105	30·135	30·100	30·023	29·976	29·943	29·883	30·021
Ballarat ..	1,430	29·903	29·947	30·042	30·113	30·079	30·088	30·112	30·065	30·015	29·984	29·950	29·901	30·017
Geelong ..	90	29·958	30·001	30·010	30·099	30·126	30·122	30·072	30·062	29·985	30·002	29·984	29·882	30·026
Melbourne	115	29·913	29·962	30·037	30·101	30·106	30·078	30·097	30·067	29·996	29·965	29·952	29·896	30·014
Hobart ..	160	29·832	29·918	29·941	29·945	29·992	29·955	29·929	29·931	29·839	29·832	29·799	29·803	29·893
Launceston	33	29·926	29·968	29·912	29·997	30·006	30·004	30·017	29·984	29·864	29·868	29·876	29·715	29·931
Bulli (Wollongong)	33	29·923	29·885	30·037	30·092	30·136	30·092	30·080	30·089	30·019	29·988	29·978	29·905	30·027
Sydney ..	146	29·901	29·943	30·020	30·073	30·082	30·060	30·079	30·076	30·016	29·966	29·953	29·881	30·004
Newcastle ..	112	29·915	29·961	30·038	30·095	30·107	30·082	30·109	30·103	30·041	30·002	29·974	29·905	30·028
Brisbane ..	137	29·898	29·923	29·990	30·083	30·136	30·101	30·110	30·138	30·080	30·015	30·003	29·922	30·036
Rockhampton ..	37	29·835	29·858	29·929	30·042	30·103	30·105	30·122	30·134	30·085	30·013	29·991	29·895	30·012
Thursday Island	17	29·767	29·782	29·799	29·829	29·880	29·986	29·913	29·926	29·918	29·892	29·854	29·810	29·856

Graph showing Mean Monthly Atmospheric Pressure of Principal Cities in Australia.



NOTE. —Each vertical space represents ·05 of an inch or 1·26 millimetres.

FIG. 14.

12. Winds.

The most conspicuous winds of Australia are the south-east trades which blow almost continuously over the northern half of the continent, and the westerly winds, or "roaring forties," which, during the winter months, extend northwards over the whole of the southern areas. Both these winds, however, are strongly deflected by continental or monsoonal influences, so much so that in summing up the average prevailing direction of wind in different parts of Australia, particularly over the southern portions, these two great systems of wind circulation are almost obscured.

On the south coastal areas, for example, we find that the average prevailing direction has a strong southerly component during the summer months and northerly component during the winter months: to the north of the continent a strong northerly component during the summer months and southerly during winter months. On the New South Wales coast the mean direction in summer is from the north-east, and in winter from the west.

On the Western Australian coast the mean direction during the summer months is from south-west to south-east, and during the winter from north-north-west to north-north-east.

Inland the mean direction of wind is largely dominated by the seasonal distribution of pressure, thus, during the winter months, when anticyclones are constantly building up pressure in the interior, there is a decided spiral contra clockwise circulation from the centre towards the coast line of the continent.

During the summer time, owing to the strong convectional action in the interior and consequently lowered pressure, the circulation is reversed and a clockwise spiral circulation obtains from the ocean to the centre of the continent. Minor factors of wind control are occasional cyclones chiefly on the east and north-west coast lines, and tornadoes which may occur in any part of Australia during the summer months, but most frequently over inland areas. These tornadoes generally develop in extensive barometric col areas or over zones where the pressure is uniform and without isobaric control, or in the north-eastern or northern gradients of cyclonic depressions moving across the southern interior of the continent, the gradients again being very slight. They generally travel on a north-north-west to south-south-east course, and at times are so strong as to level strips of country forest and destroy townships.

A north-east sea-breeze (black north-easter) is a notable feature of Sydney Harbor weather. It starts to blow about 10 a.m. on bright summer mornings, gradually increasing in force until 3 p.m., when it often reaches a velocity of 30 or 40 miles per hour; from that hour it gradually moderates, and generally ceases with sundown. The depth of this wind is comparatively slight, and, moreover, it does *not ordinarily penetrate inland* beyond a distance of 10 to 20 miles.

13. Southerly Bursters.

Southerly bursters are a distinctive feature of summer weather on the coast of New South Wales, occurring most frequently between the months of September and February inclusive, and between the hours of 7 p.m. and midnight.

As the name implies, the wind comes suddenly from the southerly quarter, causing a fall in temperature of from 20 to 40 degrees in the 24 hours, the most rapid decline taking place during the first hour of the blow. The mean velocity is about 32 miles per hour, and many of the gusts may reach a rate of 80 miles and over per hour. The blows may last for a few hours only or for several days, the duration being dependent upon the extent of the anti-cyclone to the west.

Thunderstorms frequently accompany the bursts, but useful rains only occur when the centres of the high pressure are travelling in high latitudes.

The rate of translation of a burster along the coast is about 20 miles per hour, but has no relation to the velocity of the prevailing wind. A mild burster may be translated at a rate of 60 miles per hour from point to point on the coast or may occur simultaneously. On the other hand, a violent burster may be translated from place to place under a rate of 20 miles per hour.

The explanation is as follows:—

Bursters, while being undoubtedly deflected sea-breezes, occur generally with the passage of the axis of V-shaped depressions backed up by anti-cyclones to the west of them. The change of wind takes place from a northerly to a southerly component at the moment when the axis happens to coincide with or cross any point, but as the axes of these depressions are constantly varying in their angular relation to the coastline, it follows that the rate of translation must vary accordingly. If the axis takes the same angle as the coastline the burster occurs almost coincidently on all parts of the coast. If the axis is vertical or runs from north-west to south-east, translation is from south to north; this is the general experience, but it has happened that the bursters have worked down the coast, owing to the axes of the depression on such rare occasions running from a south-west to a north-east direction.

Southerly bursters are most frequent during seasons of sporadic rains in the interior, and least frequent during exceptionally rainy seasons in the interior, which is strong evidence that they are a response to intense heat convectional action inland.

The average number of visitations in a season is 32, the greatest number, 58, was recorded in the year 1896, and the least, 16, in the year 1890, when vast areas of western New South Wales were under the flood waters of the Darling River.

They can always be looked for on hot days, but the most reliable attending indications are, first, the proximity of a V depression or relatively low barometers in comparison with those over Victoria. A foggy morning following a hot day is also a sure sign, and the local barometer invariably starts to rise slowly several hours before their advent. With these known facts they now rarely arrive without ample warning being given.

They are analogous to the Pamperos of Argentina.

The term "Brickfielder" now applied to hot dusty northerly winds on he gold-fields of Victoria was the first name given to southerly bursters in Sydney. They were then called brickfielders because brickfields in the early days were worked to the south of the infant city, and with the arrival of southerlies clouds of dust from these fields were brought to the northern

end of the town. With the migration of citizens of Sydney to the gold-fields of Victoria half-a-century ago these miners transferred the name to the hot dusty northerlies prevailing there.

The Fremantle doctor is the name given to the local sea-breeze at the chief Western Australian port. It is a cool wind from the south-west, generally starting soon after midday during the summer months, and, of course, moderating with the declining sun.

The name of "Cock Eye Bob" is the name given to thunder squalls which occur frequently on the north-west coast of Western Australia during the summer months.

14. Hurricanes.

The two zones of Australia subject to visitations of hurricanes are the north-west coast of Western Australia and the north coast of Queensland. The hurricanes on the former are known as "willy willies," and are, perhaps, the more violent of the two. The storms occur between the months of November and April inclusive, but more frequently during January and March.

They appear to originate in the vicinity of Cambridge Gulf, or even as far east as Darwin. They then start on a parabolic course along the north-west coast line, gradually intensifying until they reach the latitudes of Condon and Cossack, where they generally reach their greatest energy and cause considerable damage to the pearling fleets as well as to property on shore. From this position on the north-west coast they then usually recurve inland, gradually expanding in dimensions, and, travelling through the Murchison and Coolgardie gold-fields, where they precipitate at times torrential rains, finally pass into the Great Bight, thence following the course of the southern depressions.

Whim Creek on the north-west coast has frequently received 10 inches of rain from the passage inland of these hurricanes. On 3rd April, 1898, 29·41 inches were registered for the 24 hours, together with a fall of 7·08 on the previous day, a total of 36·49 inches within 48 hours.

The isobaric indications are a high-pressure system over sub-tropical areas, and an incipient low on the north-west coast. When local barometers show signs of falling with an easterly wind, conditions are conducive to the development or approach of "willy willies," and precautions should be taken accordingly.

A rapid fall with increasing force of wind from the east may be regarded as a definite indication of a heavy blow.

The pearl divers affirm that 24 hours' notice is always given of the approach of these storms by a sub-ocean swell, and mariners further say that the sky assumes a pale-green aspect for a day or so before the hurricane arrives.

The hurricanes on the north-east coast occur most frequently between January and April, but occasionally they may appear as late as June. The embryo stage begins generally in the South Seas in latitude 8° or 10° S.; they follow the same parabolic course as the western hurricanes, and almost invariably strike the coast between 15° and 20° S. latitude, in which zone they exhibit their most violent phases, but they not infrequently first present themselves as far south as Brisbane, travelling thence down the

east coast as far as Sydney, and finally passing off into the Tasman Sea. The rain from these hurricanes is in all cases very heavy over coastal and highland areas, over which their influence extends.

One of these hurricanes struck Port Douglas on 16th March, 1911. Besides the loss of two lives it practically destroyed the township, together with all the meteorological equipment, so that no local rain was recorded, but at South Mosman, 8 miles distant, the total rain registered in 24 hours was 16·10 inches, while during a similar visitation towards the end of the month, over 63 inches fell at the same place in five days, distributed as follows:—3·44 on 30th; 9·00 on 31st; 31·53 on 1st April; 13·74 on 7th; and 5·64 on the 3rd. During the fall of the 31·53 inches the following measurements were recorded:—8·28 inches in 7½ hours, 9·70 in 3 hours, 3·93 in 2 hours, and 9·62 in 11½ hours.

The Admiralty Hydrographic Office, in 1897, published the following remarks and advice concerning tropical hurricanes on the Queensland coast:—

Tropical hurricanes on the coast of Queensland may be expected during the summer months, namely, December, January, February, March, and the early part of April. These storms appear to originate between latitudes 8° to 12° S., and between the meridians of 155° E. and 170° W. On reaching the Queensland coast they may strike the land at any point between latitudes 12° and 26°—that is, between Cape Grenville and Wide Bay. To the southward of latitude 26° S. these storms break up into heavy gales. If, during the summer months, and the early part of April, a heavy swell sets in from north-east, and there is little or no wind at the time, bad weather is certain, for the sea always is in advance of a cyclone. With the glass steadily falling, heavy rains, and murky sky, winds between south-south-east and east a cyclone may be expected. These storms may extend some distance inland, but their centres do not often pass the coastal ranges, which appear to repel them, and they usually emerge from the coast between Broadsound and Cape Moreton. If the barometer is high over a considerable portion of the coast, the storm will recurve some distance off the land, and the wind will be from south-east to south. If, on the contrary, the barometer is low in front of the storm, it will blow home on the land as far as the coast range, and cause floods. When this happens the first of the gale will be southerly, the latter part northerly. The bearing of the storm centre will be at right angles with the waves line. Thus, on a fine day if there is a heavier sea than usual breaking on the beach, and it is coming from the north-east, if the direction remains the same or nearly so, and the barometer is not above 30 inches, the gale will blow home on the land, and the first signs of bad weather will not precede the gale by more than 12 hours, but if the direction of the swell changes to the eastward the storm is recurving, and the body of it will not reach the land. When the swell is from the east the storm centre is past; when there is anything southing in the line of the swell the storm has passed. No matter how threatening the weather signs may be, if the line of swell comes first from the southward, there will be only an ordinary south polar storm, with a low temperature.

CHAPTER V.

AUSTRALIAN VEGETATION.

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SYNOPSIS.

1. INTRODUCTORY: AREA: THE GEOCOL.
2. BOTANICAL STATISTICS.
3. VERNACULAR NAMES FOR AUSTRALIAN PLANTS.
4. SOME PROBLEMS OF THE PASTORAL INDUSTRY.
5 WEED LEGISLATION.
6. RINGBARKING.
7. DESTRUCTION OF FORESTS.
8. SCRUB AND BRUSH.
9 NATURAL HYBRIDS.
10. USE OF THE TERM "DESERT" IN AUSTRALIA. ADAPTATION TO ENVIRONMENT.
11. ORIGIN OF THE AUSTRALIAN FLORA.
    (a) THE ORIGINAL AUSTRALIAN ELEMENT.
    (b) THE AUSTRO-MALAYAN (INCLUDING PAPUAN) ELEMENT.
    (c) THE ANTARCTIC ELEMENT (SO CALLED).
12. AFFINITIES WITH THE SOUTH AFRICAN FLORA.
13. THE AUSTRALIAN FLORA AS A WHOLE.
14. THE FLORA OF THE INDIVIDUAL STATES—
    (a) WESTERN AUSTRALIA.
    (b) SOUTH AUSTRALIA (INCLUDING PART OF THE NORTHERN TERRITORY).
    (c) VICTORIA.
    (d) TASMANIA.
    (e) NEW SOUTH WALES.
    (f) QUEENSLAND.

1. Introductory; Area; the Geocol.

The first impression of Australia is the vastness of its area—it covers about 3 millions (2,974.600) of square miles, the area of the United States being 2,973,890, while that of Europe is 3,860.368 square miles.

The population of Europe is approximately 452 millions; that of Australia being 4½ millions; while our island continent is infinitely less intersected by gulfs, rivers, roads, and other means of communication. It is, therefore, not to be surprised at that much country is imperfectly explored botanically, and generalizations have often to take the place of the statements of fact which are available in older and comparatively densely populated territories.

A glance at a map of Australia will show that, with the exception of Tasmania, the boundaries of the States are almost entirely artificial and not physical ones. If we contemplate the central State, South Australia, its boundaries between Western Australia on the one hand, and Queensland, New South Wales, and Victoria on the other, consist entirely of straight lines, while most of the dividing line between New South Wales and Queensland is similarly artificial.

Nevertheless, it is found convenient in practice to register the records of species according to the political divisions, and later on, vague as these records are, and must be, as the interior boundaries are approached, it will be found that they will facilitate the definition of truly scientific botanical areas, on ecological and other lines. Much more attention requires to be paid to the work of defining the range of individual plants, and it would be desirable to see established throughout the continent agencies or outposts in touch with organizations for the record of official or unofficial botanical surveys.

Australia has been divided by Gregory* into three main divisions.

1. *The Western Plateau.*—A vast plateau which comprises more than the western half of the continent, formed of very ancient rocks, and which does not appear to have been below sea-level during recent geological times, except in the north-western part. On the north-west and south of the Australia coast, plains skirt the foot of the plateau, containing marine rocks of several distinct periods. Owing to the arid nature of the climate in the interior, the surface of the remains of the plateau is generally level.

2. *The Great Plains*, extending from the Gulf of Carpentaria across the continent to the Southern Ocean, between the mouth of the Murray and the coast of Western Victoria.

3. *The Eastern Highlands* which occur between the Great Plains and the eastern coast; they extend from Cape York Peninsula on the north, to Bass' Straits on the south, and are continued still farther by the island of Tasmania. A smaller highland area joins the western plateau in the vicinity of Spencer's and St. Vincent's Gulfs as far as Lake Torrens, the Flinders' Range being the highest land.

Griffith Taylor has put the classification into a somewhat different form—

(*a*) The Eastern Highlands.
(*b*) Murray-Darling Lowlands.
(*c*) South Australian Highlands and Rifts or the Cambrian Divide.
(*d*) The Great Artesian Basin.
(*e*) The Great Tableland or Plateau Region.

The Geocol.—Taylor† has applied the term Geocol to gaps in the Main Divide of Eastern Australia. Thus there are northern, central, and southern highlands or plateaus in New South Wales, which form "land massifs" and which are separated from each other by broad relatively depressed areas (geocols). He has given further particulars in regard to five geocols of south east Australia and their influences on intercommunication.‡

E. C. Andrews has also worked at the eastern Geocols, which are as follows:—

1. The Kilmore, Victoria, Gap or Geocol is about 1,200 feet above sea-level and a few miles wide. The Melbourne express passes it about 60 miles from Melbourne.
2. The Cooma or Monaro Geocol, New South Wales, (or Australian Rift, as Taylor has it), is about 2,000–2,600–3,000 feet above sea-level, is of fair width, and stretches from Omeo through Bombala to Cooma.
3. The Lake George Geocol, New South Wales, is about 2,000 feet above sea-level.
4. The Cassilis or Hunter Geocol, New South Wales, is about 20–30 miles broad and 1,700 feet above sea-level, and is responsible for the long dry loop extending from Gilgandra almost to Newcastle.

New England from the head of the Allyn, the Chichester, and the Paterson, to Cunningham's Gap (2,000 feet), in South Queensland, presents an excessively rough and high plateau front to the coast.

* "Geography, structural, physical, and comparative," p. 258 and plate XXIX.
† *Proc. Linn. Soc., N.S.W.*, XXXI, 517. "Australia, physiographic and economic," p. 225.
‡ "Physiog. of Eastern Australia," *Bulletin No.* 8, Commonwealth Bureau of Meteorology.

5. Another broad gap occurs near Toowoomba, Queensland, and is traversed by the Brisbane train from Toowoomba to Warwick. Greatest height, 2,000 feet.
6. The Rockhampton–Longreach Railway, Queensland, also traverses a gap about 1,500 feet in height. Its width is not known to the writer.
7. The Cairns-Chillagoe Line, Queensland, rises on to the Kuranda Gap (1,100 feet), which is in the form of a broad valley lying between plateaus on each side. Heights from 4,000–5,000 feet.
8. The Townsville-Charters Towers Railway, Queensland, also passes in a deep wide valley of low height between high ranges.

The number of gaps or geocols existent has not yet been determined, but it is desirable to draw attention to their importance in regard to the distribution of plants. The writer has specially worked at the Cassilis geocol in this connexion, and has a considerable list of western New South Wales plants which have used this gap for the purpose of migrating towards the coast.

2. Botanical Statistics.

Seven thousand eight hundred and thirty-seven species were described in Bentham's *Flora Australiensis*. In 1889, at page 8 of his fourth supplement to his *Systematic Census of Australian Plants*, Mueller gave the number of vascular plants as 8,909; genera, 1,394; families, 149.

Divided into States, he gave—

Western Australia	3,559
South Australia	1,904
Tasmania	1,030
Victoria	1,904
New South Wales	3,260
Queensland	3,711
North Australia	1,977

Based on the work of the Government Botanists of the various States, the following estimates of described species may be submitted as approximately true to-day; if the present activity continues during the next few years the numbers will be much increased.

Western Australia	3,900
South Australia	1,985
Tasmania	1,210
Victoria	2,000
New South Wales	3,600
Queensland	4,480
North Australia	2,050

Mueller includes the floras of Lord Howe and Norfolk Islands, which should be deducted from the total of 8,909 to the extent of about 92 species peculiar to those islands; we thus have 8,817 as Mueller's real total of Australian plants irrespective of the numbers of plants found in individual States.

To this total may be added 1,856, the number of additional species of which the present writer has record since the date of Mueller's Second Census. The number is undoubtedly understated, since this record must be imperfect, in spite of the fact that it is carefully kept. This makes the number of phanerogams and vascular cryptogams recorded for Australia as 10,673.

Time has not been available to separate the additions into their various States, nor to add to Mueller's totals of species for the various States, the additions recorded by the writer to the States' localities of those species as given in the Second Census.

Of this number (8,909) Mueller stated that 7,501 are endemic, and, of the remaining 1,338, or 15·1 per cent., there are found in Europe 160; Asia, 1,032; Africa, 515; America, 315; Polynesia, 558; New Zealand, 291. These figures have not been brought up to date.

Mueller gave the following families with species as under (all after the plus marks are the writer's) :—

1.	Leguminosæ	1,084	+	192	=	1,276	(1)
2.	Myrtaceæ	666	+	150	=	816	(2)
3.	Proteaceæ	599	+	68	=	667	(3)
4.	Compositæ	541	+	94	=	635	(4)
5.	Cyperaceæ	379	+	42	=	421	(7)
6.	Gramineæ	352	+	81	=	433	(6)
7.	Orchideæ	287	+	152	=	439	(5)
8.	Epacridaceæ	275	+	26	=	301	(8)
9.	Euphorbiaceæ	226	+	25	=	251	(11)
10.	Goodeniaceæ	219	+	75	=	294	(9)
11.	Filices	212	+	43	=	255	(10)
12.	Rutaceæ	190	+	42	=	232	(12)
13.	Liliaceæ	163	+	26	=	189	(13)
14.	Rubiaceæ	127	+	20	=	147	(16)
15.	Sterculiaceæ	125	+	30	=	155	(14)
16	Labiatæ	125	+	23	=	148	(15)
17.	Chenopodiaceæ (Salsolaceæ) ..	113	+	33	=	146	(17)
18.	Malvaceæ	110	+	13	=	123	(20)
19.	Umbelliferæ	107	+	38	=	115	(18)
20.	Sapindaceæ	101	+	25	=	126	(19)
21.	Amarantaceæ	100	+	19	=	119	(21)

Below this there is no great break, the list ending with fourteen families, with, so far, only one species each.

It will be observed that these additional numbers of species since described alter the sequence somewhat. Thus the activity of botanists dealing with the Orchideæ raises that family above both the Gramineæ and the Cyperaceæ, its position and that of the Cyperaceæ being transposed. Thus Orchidaceæ now should have fifth place, Cyperaceæ seventh. Goodeniaceæ now comes ninth, Filices tenth, Euphorbiaceæ eleventh. Sterculiaceæ now occupies the fourteenth place, Labiatæ fifteenth, Rubiaceæ sixteenth, Chenopodiaceæ seventeenth, Umbelliferæ eighteenth, Sapindaceæ nineteenth, Malvaceæ twentieth, Amarantaceæ twenty-first.

Some of the largest genera comprise the following species (in some cases the numbers are approximations, the writer having been unable to critically examine them):—

> *Acacia*, 412; *Eucalyptus*, 230; *Grevillea*, 193; *Styphelia* (in the Muellerian sense), 193; *Melaleuca*, 112; *Candollea* (*Stylidium*), 112; *Goodenia*, 112; *Hakea*, 107; *Hibbertia*, 104; *Pultenæa*, 93; *Eremophila*, 91; *Schœnus*, 77; *Pimelea*, 76; *Ptilotus*, 76; *Panicum*, 75; *Boronia*, 72; *Eriostemon* (in the Muellerian sense), 72; *Cyperus*, 72; *Aster*, 71; *Helichrysum*, 70; *Scævola*, 68; *Bæckea*, 66; *Daviesia*, 64; *Cryptandra*, 63; *Drosera*, 62; *Persoonia*, 62; *Ficus*, 62; *Fimbristylis*, 58; *Haloragis*, 56; *Solanum*, 55; *Helipterum*, 53; *Dodonæa*, 51; *Prostanthera*, 50; *Phyllanthus*, 50; *Dryandra*, 49; *Banksia*, 48; *Dendrobium*, 45; *Jacksonia*, 44; *Brachycome*, 41; *Bossiæa*, 41; *Hibiscus*, 39; *Gastrolobium*, 37; *Lasiopetalum*, 35.

Approximately 700 species have been recorded in lists of species recorded under States, as common to western and eastern Australia, but because of the vagueness of the State boundaries already referred to, and because of the imperfection of the record, especially as the interior is reached, such statistics are very imperfect, and certainly of limited value unless recorded for definite plant-zones.

The genera (taking cognisance only of those represented in the 700 by 4 or more species) include *Sida*, *Abutilon*, *Dodonæa*, *Claytonia*, *Ptilotus*, *Atriplex*, *Rhagodia*, *Kochia*, *Bassia*, *Salicornia*, *Pimelea*, *Swainsona*, *Cassia*, *Acacia*, *Haloragis*, *Melaleuca*, *Eucalyptus*, *Hydrocotyle*, *Loranthus*, *Brachycome*, *Aster*, *Helipterum*, *Helichrysum*, *Angianthus*, *Senecio*, *Goodenia*, *Eremophila*, *Myoporum*, *Styphelia*, *Pterostylis*, *Xerotes*, *Triglochin*, *Juncus*, *Centrolepis*, *Cyperus*, *Scirpus*, *Gahnia*, *Carex*, *Panicum*, *Andropogon*, *Stipa*, *Poa*, *Eragrostis*.

Few of the genera are confined to country of low rainfall, but the species contained in the 700 and comprised in the above genera are preponderatingly those of country of low rainfall, and it would be interesting to endeavour to ascertain how far west from the South Australian border the species extend into Western Australia, and how far east from the South Australian border the same species extend into Queensland and New South Wales.

3. Vernacular Names for Australian Plants.

The person who complains (without qualification) of the confusion of common names applied to Australian plants, sometimes loses sight of the fact that Australia is as large as Europe, and that even in Europe the application of vernacular names to plants is often profuse and bewildering. The Briton, Greek, and Scandinavian have different languages of course, but their plant names are (like those of Australians) often uncertain and difficult of interchange. Our difficulties have arisen partly because the continent only began to be settled about a century and a third ago, and then by a handful of people, very few of whom were educated; they came to a continent whose flora was unknown, even to botanists, and, as they spread into new areas they gave similar names to trees which appeared to them to be similar, and which, in most cases, have only recently been shown to be different.

The predominant vegetation (Eucalyptus) has a very similar facies, and it is not to be wondered at that the ordinary citizen has shown no greater knowledge of it than the botanist.

Then again the early colonists had a limited vernacular, because they could only use comparative terms, and the trouble was that the plants of their native countries were about as unlike those of their new homes as it was possible for them to be.

Even the aboriginal owners of the soil were split up into tribes with different languages, and in the comparatively few cases in which they had names for plants at all, these names did not pass current over large areas.

In some cases the aboriginal names have been adopted by the white population. Some attempt has been made to standardize the vernaculars for Australian plants, but the chief difficulty arises from the fact that all over the world experience shows that most plant names are restricted to small areas. However, with the spread of education, it is confidently expected that the use of botanical names, at least as to genus, will present fewer difficulties. Of course, it must be borne in mind that the study of natural history has an attraction for only a limited portion of the population, while of the naturalists but few take special interest in plants, and fewer still in their vernacular nomenclature.

4. Some Problems of the Pastoral Industry.

Australia is a great pastoral country, and, as in other countries, a small percentage of sheep and cattle is lost every year through their feeding on certain plants. Further investigations are being carried out on this subject, but the following facts may be stated :—

1. Certain forage plants (grasses and others) contain cyanogenetic glucosides. Poisonous results take place at certain seasons of the year (though perhaps not every year), as regards the same plant in a given area.
2. A few plants contain saponins and even more virulent poisons, *e.g.*, certain Leguminosæ (*Gastrolobium, Isotropis, Oxylobium*), particularly in Western Australia.
3. Some succulent plants, *e.g.*, *Euphorbia Drummondii*, Boiss., are apparently responsible for many deaths among stock, but it has been shown that the cause of death is hoven, and that only tired and hungry animals, which eat immoderately, are affected by them.
4. Certain Leguminosæ (*Swainsona*) derange the nervous systems of stock eating them; the animals develop an inordinate appetite for the plants, eventually becoming so-called Pea-eaters, or Indigo-eaters, and absolutely useless to the owner, death finally supervening. The symptoms are analogous to those known as Lathyrism, Nenta, Loco disease, in other parts of the world.

The United States, South America, and South Africa have problems of a like nature before them, and the difficulty is not solved when the plant-culprit, be it poisonous or not, is detected. The problem to be solved is how

to prevent the deaths of stock by applying either a preventative or an antidote. With large flocks and herds spread over large areas, individual treatment has special practical difficulties of its own.

It is a very common and empirical practice to attribute the deaths of stock to poison plants. As a matter of fact, Australia appears to possess singularly few poison plants which are injurious to stock, or which contain active principles which may be utilized as drugs.

5. Weed Legislation.

As Australia becomes developed, there is an increasing tendency in all the States to increase local self-government and coping with weeds becomes usually one of the functions of local bodies. The underlying idea is that local people know what plants are most noxious to them, and the function of the State Governments is indorsement of their recommendations for proscription of specific weeds, subject to power of veto. This affords the necessary Government control, preventing local bodies, which may not have special knowledge, taking action prejudicial to their own interests.

The Prickly Pear (*Opuntia*) is dealt with by special legislation, both in New South Wales and Queensland. What has been stated so far refers to weeds after they have got a footing in Australia.

To prevent the entry of undesirable plants into the Commonwealth, the Federal Government in 1908 passed "An Act relating to Quarantine." An Appendix to this Act forbids the entry of plants affected by certain diseases (chiefly caused by fungi), and mostly affecting economic plants. Another Appendix prohibits certain weeds. These weeds have, however, already got a firm hold in the Commonwealth, and some are very widely diffused; the object is to put difficulties in the way of the importation of known pests into clean areas, leaving the circulation of weed-pests already in the Commonwealth the business of the State Governments.

Many of the Australian weeds were introduced into the country in the very first years of settlement. They came from Britain in the packing of goods sent in the first fleet, from Rio de Janeiro, the Cape, and Calcutta, the two former being ports of call on the outward voyage, and the two latter being visited from Sydney for food supplies. Later on a trade in horses with Chilian ports was responsible for the introduction of such plants as *Xanthium spinosum*.

As time went by, no restriction of any kind was placed on the introduction of plants, and gradually the varieties of weeds increased to the present formidable total, and, being let loose on a virgin continent, brought about unexpected results.

The importation of enormous fodder supplies during periods of drought has been a prolific source of introduction of weed seeds, not only from various parts of the continent enjoying a good season, but also from beyond seas. All the States contain large areas of unalienated lands, and these are sometimes an Alsatia for weeds, to the prejudice of the adjoining private owner. With the increase of population, this difficulty will largely disappear.

Prickly Pear.—Members who visit the valley of the Hunter and north-western New South Wales and Queensland can scarcely avoid seeing the pest known as Prickly Pear, for its spread is one of the most remarkable instances

of plant-aggressiveness known in any part of the world. A form of *Opuntia inermis*, P. DC., has already devastated these two States to such an extent as to cause both Governments real anxiety, for the efforts of man have not stemmed the rapidity of spread to any considerable extent. In New South Wales there are about 2,500,000 acres of pear-infested country, and two years ago a Minister of the Crown estimated the cost of eradicating the pear in that State to be ten or twelve millions sterling. In Queensland, it is stated that 30,000,000 acres are affected, and further, that the spread is one million acres per year. This never-ending advance of the pest is its most serious feature.

What has given pear its chance is the fact that in Australia it has practically a virgin continent in which to spread. It does not attain its best development in the coastal districts, which have a comparatively high rainfall, and a fairly dense population. In the regions climatically suited to it, there are but few people, and in broken country it gets a practically impregnable hold. So tenacious of life is it, and so adapted to its environment, that so far no economical method of destruction has been discovered, and the difficulty of the problem is enormously increased by the fact that the sides and tops of hills, gullies, country fissured and difficult of access, have to be left as breeding-places for the pest.

Less than a dozen species of *Opuntia* have escaped from cultivation and spread to any extent, but all the others put together have not spread a millionth as much as the species designated by the writer as Pest-pear.

Prickly Pear was introduced to Australia (the number of species is unknown) from Rio de Janeiro, when Governor Philip touched at that port of his outward voyage in 1789, being brought as food for the cochineal insect he desired to introduce with the object of founding an industry.

O. aurantiaca, Gillies, is a small spiny species with brittle joints, which is spreading both in New South Wales and Queensland, and is a pest also. Its brittleness and spininess combine to make it a plant to be dreaded. Under the name of "Jointed Cactus" it is a pest in South Africa.

O. imbricata, P. DC., a cylindrical species with pink flowers, is confined to moderately cool districts in New South Wales; while *O. Dillenii*, P. DC., a formidable species, and *Opuntia (Nopalea) dejecta*, Salm-Dyck, are confined to Queensland so far.

O. nigricans, Haw., and *O. monacantha*, Haw., coarse spiny species, occur both in New South Wales and Queensland.

O. tomentosa, Salm-Dyck, a tall, dark-looking species covered with a velvety tomentum, is wild in Queensland and northern South Australia, but is not looked upon as a pest. *O. ficus-indica*, Mill., the "Barbary Fig," is well acclimatised and yields an edible fruit. There are a few other species of less importance.

It is not easy to understand why one species or other of *Opuntia* has not spread in one of the other States, but such is the fact, *O. monacantha* being the only formidable species which is acclimatised in Victoria, South and Western Australia, and only to a very limited extent.

The Pest-pear has a partiality for good soil, and is far less formidable in appearance than some of the species just enumerated. It is not tall, for the tall species have distinct and separate stems, while this species has

ramifying stems hard to disentangle and get at; it has comparatively few spines, but what are really feared are its barbed spinules, which are produced abundantly, and cause severe irritation in man and beast. Added to these it has a fatal facility for reproduction, being propagated by birds and stock which eat the seeds, while every joint or portion of one forms a new plant.

Eichhornia speciosa, Kunth., the so-called "Water Hyacinth," originally imported from Europe as an ornamental plant, has shown itself very adapted to Australian conditions, and from northern New South Wales to central Queensland is filling lagoons and clogging water-courses, inflicting very severe damage where fresh water for drinking purposes in lagoons and creeks is especially valuable, to say nothing of the interference it is causing to navigation in even moderately large rivers.

Some of our worst weeds include Bathurst Burr (*Xanthium spinosum*, L.), Noogoora Burr (*X. strumarium*), Sweet Briar (*Rosa rubiginosa*, L.), Blackberry (*Rubus fruticosus*, L.), Lantana (*Lantana Camara*, L.), Prickly Pear (*Opuntia spp.*), Star Thistle (*Centaurea calcitrapa*, L.), and other species of *Centaurea*, Black Thistle (*Carduus lanceolatus*, L.), Cape Weed (*Cryptostemma calendulaceum*, R. Br.), Stinkwort (*Inula graveolens*, Desf.), Sorrel (*Rumex acetosella*, L.), Dock (*Rumex crispus*, L.), and other species, Purpletop (*Verbena bonariensis*, L.), and others, Corn Gromwell (*Lithospermum arvense*, L.), Yellow Poppy (*Argemone mexicana*, L.), Tree Tobacco (*Nicotiana glauca*, Grah.), Mallow Weed (*Modiola caroliniana*, L.), Thorn Apple (*Datura stramonium*, L.), Nut Grass (*Cyperus rotundus*, L.), Wild Oats (*Avena fatua*, L.).

6. Ringbarking.

Visitors to Australia will be interested to see the enormous areas of forest land which have been subjected to the process of ringbarking or girdling. In the utilization of land for arable purposes the trees are usually removed altogether, but over large pastoral areas the lives of the trees have been sacrificed simply in order that the grass may grow: in many cases not because of the injury caused to the grass by the shade of the canopy, which is often small, but because the trees compete with the herbage for the plant food and moisture.

Most of the trees being durable hardwoods, they die as they stand, and may expose their gaunt arms and grey trunks for up to half-a-century and even more, littering the pasture until such time as fungi, beetles, and the elements combine to reduce them again to mother earth.

7. Destruction of Forests.

The deliberate destruction has arisen from two causes—(1) the destruction of trees to convert them into timber; and (2) the destruction of trees and shrubs in the formation or improvement of pastoral and arable land.

In (1) the requirements of engineering and mining works, building, fencing, furniture, etc., have to be provided for. Under (2) the burning off has been incessant, but a fair percentage of dead timber has been converted into household fuel in the vicinity of towns. In Western Australia the cutting of green timber for fuel purposes in the vicinity of the gold-fields is, because of the local scarcity of coal, carried out to an extent unknown in eastern

Australia. Since the removal of all large timber in the vicinity of the goldfields areas is complete, data should be obtainable in regard to the rate of growth of many species in definite areas, natural re-afforestation being usually allowed to proceed. In South Australia alone there are large forest plantations, this being largely a treeless State. Victoria and New South Wales are doing some planting.

The compensating extent of natural re-afforestation is considerable, although sometimes lost sight of. Some species, e.g., *Eucalyptus pilularis*, Sm., re-afforest rapidly in forest land, and it is believed that the seeds of forest trees, which pass through sheep and cattle, and which are trampled into the soil, are responsible for the conversion of large areas of grass land into forest in the eastern States.

The removal of the trees of a forest destroys the plant equilibrium, and interesting changes, which, however, cannot be discussed at this point, take place, particularly in the brush.

8. Scrub and Brush.

The term scrub has something of inferiority in its meaning, referring primarily to small or stunted vegetation, whether of trees or shrubs; in Queensland, it has become applied to the luxuriant vegetation of the jungle. In New South Wales it is applied more generally to the comparatively sparse vegetation of the more sterile areas, such as those of the sandstone and granite. It is also applied to the open forest, in which the species are more gregarious as a rule than those of the brush.

The Brush.—The brush corresponds to what in India is called jungle, and consists of well-watered rich-soil areas, chiefly in the coast belt and coast table-lands of eastern Australia, which support not only rich arboreal vegetation, but also creepers and climbers of various kinds, and shrubby undergrowth. The tree vegetation is of the most varied character (e.g., Meliaceæ, Sapindaceæ, Saxifragaceæ, Cunoniaceæ, Lauraceæ, Monimiaceæ, Coniferæ (*Podocarpus*), Taxaceæ (*Araucaria* and *Callitris*), but rarely includes Eucalypts. The term brush is almost entirely confined to New South Wales and Queensland; in New South Wales it is used largely; in Queensland the term scrub is often substituted.

In the brush forests of the northern coastal districts of New South Wales and coastal Queensland generally the buttress-stem is often seen. Frequently these buttresses are of considerable size; nearly vertical and quite thin, almost like stalls in a stable. They are commonly seen in Figs (*Ficus*), and also Yellow Carabeen (*Sloanea Woollsii*, F. v. M.), Booyong (*Tarrietia argyrodendron*, Benth.), Red Cedar (*Cedrela Toona*), She Beech (*Cryptocarya spp.*), Marara (*Weinmannia Benthami*, F. v. M.), and many others. Sometimes these buttresses extend in fantastic shapes along the ground and, in the case of the Yellow Carabeen, they may be so delicate as to be not more than an inch thick where they enter the ground.

They form natural struts to the trees in areas of well-watered good soil and warm temperature, where the competition amongst tree individuals is very keen. Very long trunks run up towards the light and, even with their diminished crowns, the leverage of such long stems renders the buttress essential to the stability of the tree.

Lianes are not unusual in the brushes, being generally the stems of a species of *Vitis;* these contain water, and the bushman cuts them into lengths and *more suo* obtains drinking-water from them. They grow in the warmer coastal brushes, where the rainfall is good: at the same time, running water may be as much as a few miles away.

In moderately dry and very dry country the aborigines, and the white men on occasion, dig up the roots of certain trees, and obtain sufficient drinking water therefrom. The trees usually employed are certain Mallees or dwarf Eucalypts, particularly *E. incrassata*, Labill., var. *dumosa*, and *E. oleosa*, F. v. M., also *Hakea leucoptera*, F. v. M. (one of the needle-bushes), *Casuarina Decaisneana*, F. v. M. (a Desert Oak).

9. Natural Hybrids.

Bentham (B. Fl.) wrote that little as we know of the influence of natural hybridism in Europe, it has been still less, if ever, observed in Australia.

This statement is not as true to-day, as regards either Europe or Australia, as when it was written, and some observations are now available, particularly in connexion with Eucalyptus. Care must of course be taken that the attribution of natural hybridization is not a too hurried jumping to conclusions without adequate evidence.

The subject demands careful field knowledge, and it would appear that the phenomenon has already been proved, without reasonable doubt, in a number of cases, chiefly Eucalyptus, and attention is briefly drawn to the matter because of its very great importance.

10. Use of the Term "Desert" in Australia.

The underlying meaning of this word is absence of vegetation, and classical examples are those of the Sahara of North Africa, and the Gobi desert of Central Asia.

In Central Australia there are extensive regions of low or intermittent rainfall, some of moving sandhills and, especially towards the centre and west, of saline depressions, but very much of the country referred to as desert in the old maps is not desert in the strict sense, since it sustains a more or less sparse vegetation, with trees here and there, while immediately after rain innumerable plants spring up, carpeting the country side with individuals of Gramineæ, Compositæ, (*e.g.*, *Helipterum*, *Helichrysum*, etc., white, pink, yellow, and even other colours), Salsolaceæ, Goodeniaceæ (*e.g.*, *Velleia rosea*, S. le M. Moore, and *Goodenia spp.*), Amarantaceæ (purple and pink *Ptilotus*), Cruciferæ, etc.

The truly riverless area is chiefly comprised in eastern Western Australia and the southern portion of the Northern Territory, while the Salt-lake system, in which a large number of rivers do not find their way to the coast, but terminate in Lake Eyre, is a considerable area a little east of the centre of the continent.

These areas support a most interesting xerophytic vegetation, and strips throughout the so-called desert are pastoral country, supporting both grass and edible shrubs. It is interesting to note how year by year the "wheat line" in all the mainland States has been pushed into the "desert," and man is getting remunerative crops from regions of low rainfall and light sandy soil which would have been looked upon as chimerical a decade ago. In

other words, the "desert" land is shrinking year by year, and a factor to aid this shrinkage will be the Port Augusta-Kalgoorlie railway line, which will link Western Australia with the eastern States. It is not possible, however, that any considerable number of visiting botanists can find time to study our "desert" on the spot, and the subject cannot be dealt with at all fully in this general article.

The permanent plants of the arid country are dependent on subterranean water, the catchment and storage of some of these supplies being both very small and purely local. In addition to these local supplies, dependent on the very intermittent rainfall, there are the vast artesian accumulations, the relation of which to the vegetation they support will furnish the student with an interesting subject for investigation. In Western Australia local natural water supplies, very circumscribed in area, are known as "soaks," and frequently form oases around which there is a specially interesting vegetation.

Vast areas of Australia have only, as regards the vegetation, two kinds of season, the dry and the rainy. The rainy season may be only a few days in the whole year, or, it may be, as it usually is, intercalated with dry periods. When these showers come, the surface of the ground is changed as if by magic, bright carpets of the small plants already referred to covering the ground with uniformity over large areas; these quickly mature, develop seeds, and perish, being represented by the seeds alone, until the next period of their life-cycle arrives with a further supply of rain. In many of these regions of small and intermittent rainfall it is obvious that no recorders of rainfall are present, and the only practicable method a student has, is to arrange with some one living in the vicinity to notify him by telegraph of a local rainfall, in order that he may hasten to the spot without delay.

Adaptation to Environment.—The adaptation to environment of desert plants in Australia, and particularly those of Western Australia, has been ably dealt with by Mr. S. le M. Moore, and doubtless our visitors will specially examine the characters of xerophilous plants in all parts of the continent conveniently accessible to them. Space only allows the briefest reference to the subject here. Henslow quotes Volkens as stating that certain xerophilous plants covered with a resinous substance, which prevents a too energetic transpiration, are peculiar to the Southern Hemisphere. Examples out of very many are *Beyeria viscosa*, *Eucryphia Billardieri* (Pinkwood of Tasmania), Dodonæa and Acacia of various species; the roots of various Gramineæ.

The young shoots of *Angophoras* and of the Corymbosæ section of *Eucalypts* are protected by a covering which contains caoutchouc.

The Blanket plants (*Lachnostachys*) of Western Australia are especially woolly, and so are the allied genera *Newcastlia* and *Dicrastylis*. Many Composites and Malvaceous plants are, with many others, very hirsute. These non-conducting coverings hinder the transpiration of moisture.

Instances of aphylly are very numerous, and are afforded by such plants as—

> Native Cherry (*Exocarpus*), Cypress Pine (*Callitris*), She Oaks (*Casuarina*), *Apophyllum anomalum*, *Tetratheca juncea*, *Comesperma* of various species, *Daviesia alata*, *Sphærolobium vimineum*, *Viminaria denudata*, *Amperæa spartioides*, and many others.

There are also many succulent plants belonging to the families Zygophylleæ, Portulacaceæ, Ficoideæ, Crassulaceæ, Salsolaceæ, Euphorbiaceæ (*Euphorbia*, &c.), Asclepiadaceæ (*Dæmia*, *Sarcostemma*).

Some plants have water-storing cells in stems or in roots, or in both. Notable examples are the Kurrajong (*Brachychiton populneus*, R. Br.), widely distributed, and the Bottle Tree (*B. Delabechii*, F. v. M., or *Sterculia rupestris*, Benth.), found in Queensland, and so called from its ludicrous resemblance to a gigantic lemonade bottle. These are not only water bearing as regards their stems, but also have succulent roots, which are sometimes eaten by the aborigines. In North-western Australia the Gouty Stem (*Adansonia Gregorii*, F. v. M.) is to be found, a characteristic feature of the landscape, while a second species (*A. Hanburyana*, Hochr.) has recently been described. Reference has already been made to the so-called water-bearing trees.

11. Origin of the Australian Flora.

(a) The Original Australian Element.

Wallace observes that South-western Australia is the remnant of the more extensive and more isolated portion of the continent in which the peculiar Australian flora was principally developed. He suggests that the existence there of a very large area of granite (800 miles in length by nearly 500 in maximum width, with detached masses 200 miles to the north and 500 miles to the east), indicates such an extension: for these granitic masses were certainly once buried under piles of stratified rock, since denuded, and then formed the nucleus of the old Western Australian continent.*

He further states that while this rich and peculiar flora was in process of formation, the eastern portion of the continent must either have been widely separated from the western, or had perhaps not yet risen from the ocean.

In Cretaceous times and far into the Tertiary, there was no Australian continent in existence, but instead, a crescentic wide belt of sea forming an archipelago, consisting of two main islands to the north, one large island, and some smaller ones to the south, and another to the north-east.†

The distribution of land and sea in the Cretaceous period is shown by Jensen,‡ based on David's maps, and during that period the Rolling Downs formations were laid down. The sea extended from Cape York from south to north of Queensland, extending over most of its area, except in the east, and covering a considerable portion of northern South Australia and north-western New South Wales.

This later map differs from Wallace's chiefly as regards his continuous eastern land area (almost the Torresian and Bassian sub-regions of Spencer, *see below*), and the deflection of Wallace's sea to the north-west. Jensen remarks that the Cretaceous sea was probably connected with the ocean, both to the south and to the north; thus an aqueous barrier between west and east is understood, which is what Wallace postulated.

Speaking of the disappearance of the Cretaceous basin, which caused a migration of the hardy plants (*Eucalyptus*, Proteaceæ, etc.), which had developed on the barren soils of Western Australia into eastern parts, where

* "Island Life," 2nd Ed., 494.
† See Wallace's map at p. 497, *op. cit.*
‡ *Proc. R.S., Q.*, xxiii, Fig. 9

they expelled and subdued the Indo-Malaysian type of flora. Jensen* points out that there is evidence that the plants they drove back were largely Lauraceæ in the fossil leaves of the older deep leads and the trachytic tuffs of the Warrumbungles of New South Wales.

Tate, in 1888,† divided the Australian endemic flora into three types—

1. *Euronotian*, occupying the coastal area of the north-east and south-east, its internal boundary coinciding with the rainfall limit of 25–30 inches per annum.

   The type flora of this is dominant in the south and east part of the continent.

2. *Autochthonian*, a small region restricted to the south-west corner of the continent, its internal boundary also coinciding with the same rainfall limit in this part.

3. *Eremian*, occupying a large stretch of country, centering in Lake Eyre, but extending right across the continent to the shores of Western Australia and over which the average rainfall is over 10 inches per annum.

Besides this endemic flora, what he styles an "immigrant" flora has two constituents—

(a) *Oriental*, dominant in the littoral tracts, but mixed there with typical Australian genera.

(b) *Andean*, restricted for the most part to the highlands of New South Wales, Victoria, and Tasmania, and with this he includes north temperate forms, *i.e.*, species characteristic of north temperate regions.

Mr. C. Hedley‡ pointed out that the regions suggested by Tate as suitable in the case of plants were not equally suitable in the case of animals. Accepting (1) and (2), he suggested that (3) should be divided into two, and suggests that for Tasmania, Victoria, and southern New South Wales the name *Euronotian* should be retained, whilst for the second portion of the division, including Queensland and northern New South Wales, he suggested the name *Papuan*.

Baldwin Spencer (also on zoological grounds) modifies Tate's proposals, suggesting § a high *Eyresian* sub-region including the greater part of the continent, with a *Torresian* (*Papuan*) sub-region, including Papua, North Australia, and eastern Queensland as far south as the Clarence River (near the Queensland New South Wales boundary), while his *Bassian* sub-region includes Tasmania, Victoria, and eastern New South Wales.

To whatever extent some of Wallace's conclusions in regard to the relations of the Australian flora in the present and past epochs may have been defective, owing to the imperfection of our geological knowledge at the time, (and both Messrs. C. Hedley ‖ and S. le M. Moore¶ have ably criticised them), the point of most importance is, as Professor Baldwin Spencer has pointed out, demonstration of the fact that for a long period of time the east and west parts of the continent were separated from each other by an

* *Op. cit.*, p. 189.
† *Proc. Aust. Assn. Adv. Sci.*, I, 312, &c.
‡ *Proc. Aust. Assoc. Adv. Sci.*, V, 444.
§ *Horn Exped. Rep.* Pt. I, 197.
‖ "*Loc. cit.*"
¶ "*Natural Science*," XV., 198 (1899).

impenetrable barrier of some description. The original division of the continent into a western and eastern half, the former containing the Autochthonian constituent, is generally admitted, and most authors agree that the separation took place in Cretaceous times.

Tate says the Eremian flora was developed in Central Australia in Pliocene times from Autochthonian and Euronotian elements, and was largely modified by Oriental immigrants.

Tertiary Flora.—von Ettingshausen recorded *Eucalyptus* and *Metrosideros* in the Eocene beds of Sheppey, England, and *Pimelea*, *Leptomeria*, and four genera of Proteaceæ were recorded by Heer in the Miocene of Switzerland. Further, Ettingshausen believed he found 55 Australian forms in the Eocene beds of Haring (? Belgium). Hooker wrote to Wallace that he considered these determinations worthless, and Bentham disapproves of similar identifications by Heer and Unger. Indeed it was for some time held that the European Tertiary flora contained *Alnus*, *Betula*, *Quercus*, *Sequoia*, *Acer*, *Pinus*, and other genera peculiar to the Northern Hemisphere, together with *Casuarina*, *Grevillea*, *Banksia*, *Dryandra*, *Leptomeria*, *Eucalyptus*, and other genera peculiar to the Southern Hemisphere.

Turning to the Antipodes, Ettingshausen* records many European forms in the Tertiary of Australia, but Deane† firmly disputes the accuracy of certain of the determinations, while, referring to the European ones, Hemsley‡ says that until more conclusive testimony is forthcoming of the former existence of Proteaceæ, Eucalypti, etc., in Europe, we cannot avoid the conviction that they originated in the south.

In the opinion of the most experienced botanists in Australia the botanical determinations and deductions built by some palæo-botanists upon mere leaf impressions are to be regretted. Except in the case of very characteristic material, botanists who deal with the existing flora usually ask to be excused from determining a plant on a leaf only.

(b) The Austro-Malayan (including Papuan) Element.

Bentham§ observes that the predominant portion of our vegetation appears to be strictly indigenous, and that the great mass of purely Australian species and endemic genera must have originated or been differentiated in Australia, and adds that it never spread far out of it.

He also states that the only exceptions observed by him are a few Australian types (*e.g.*, Eucalypti, Epacrideæ, phyllodineous Acacias, etc.) appearing in the Malayan Archipelago, especially Timor, New Guinea, and Borneo, where they have established distinct, though in most cases, nearly representative species, sometimes, however, preserving absolute identity, and a very few, chiefly annual or herbaceous plants of various Australian genera, found as far as South China, mostly in identical or very closely representative species. But little was known comparatively of the Chinese flora in Bentham's time, but through the publication of Forbes' and Hemsley's Enumeration and other works, we are now in a far better position to indicate the precise relationships of the Australian and Chinese floras. The flora of the Malay Archipelago is also now much more readily available to students. And

* "Contrib. Tertiary Flora of Australia," *Mem. Geol. Surv.*, N.S.W., Pal. No. 2.
† *Proc. Linn. Soc.*, N.S.W., XX, 648 *et seq.*
‡ Challenger Reports Botany Vol. I (Hemsley's Introd., p. 51).
§ Pref. to B. Fl., VII, p. vi.

here it may be mentioned that there are two aspects of every mutual relation; we require to accumulate additional data not only in regard to the incursions of the purely Australian element into regions beyond, but also in regard to the "foreign" element into Australia. A bridge carries passengers both ways.

In another place Bentham* observes that the principal flora showing an ancient connexion between Australia and other countries is the Indo-Australian. A number of genera whose main station is in tropical Asia extend more or less into tropical or eastern sub-tropical Asia, sometimes in identical, sometimes in more or less differentiated species. Those of coastal Queensland have generally an east Asiatic character. A few Ceylonese and Indian types are more specially represented in Arnhem's Land, but scarcely any Indian forms are found westward of that peninsula.

The whole of the islands east of Wallace's line, called the Austro-Malayan Region, essentially form part of a former Australian or Pacific continent, although some of them may never have been actually joined to it. These islands of course include Celebes, Gilolo, Ceram, and Papua. A shallow sea (under 100 fathoms) at the present time connects Papua and northern Australia as far as the "north-west" on the one side, and Queensland on the other.

Wallace remarks† that when we consider the wonderful dissimilarity of the two (Papuan and Australian) regions in all those physical conditions which were once supposed to determine the forms of life—Australia, with its open plains, stony deserts, dried-up rivers, and changeable temperate climate; Papua, with its luxuriant forests, uniformly hot, moist, and evergreen—this great similarity in their productions is almost astounding, and unmistakably points to a common origin. In this passage he, however, omits to note the fact that northern Queensland, east of the Divide, may be described in terms precisely similar to those employed by him in regard to Papua.

It is not difficult to understand how a migration of plants from Papua to northern Queensland (omitting for the moment reference to other parts of northern Australia further west) can have taken place *viâ* the land connexion or the stepping stones of Torres Straits, while the climatic conditions, although a little cooler in northern Queensland, at all events as compared with coastal Papua, are nearly similar in the two land areas. Then acclimatisation comes into play, and plants, having once bridged the gap, progress on their southward journey.

The Austro-Malayan element is common in the coastal "scrubs" (brushes) of Queensland, and is marked even in the same formations in New South Wales, but the writer is not able to submit a useful statistical account of this element in Australia at the present moment

In 1892 above 2,000 species of Phanerogams were known from Papua *i.e.*, from the Dutch, English, and German possessions; in 1911, the number of species described must be nearly 3,000, chiefly through botanical activity in the German possessions. Dr. R. Schlechter alone has contributed nearly

* Pref. to B. Fl., VII

† "Malay Archipelago," p. 580 (1886)

100 terrestrial orchids, a considerable number of which are new, the others being Malayan.

The whole of Papua is a region of tropical forests only occasionally interrupted by savannas, *i.e.*, grassland interspersed by trees. What Wallace says as regards Borneo, that an Orang-utang could cross the island from tree to tree, without putting foot to the ground, pretty well applies to Papua.

The chief savannas are at the mouth of the Fly River, and the grasses are chiefly composed of *Imperata arundinacea* (our Blady Grass), and the genera *Anthistiria* (*Themeda*, our Kangaroo Grass), *Rottbœllia*, *Andropogon*, *Apluda*, *Pennisetum*, etc., all tall grasses; while the interspersed groups of trees contain to a great extent the genera *Eucalyptus* (*E. tereticornis*, Sm., *alba*, Reinw., *clavigera*, A. Cunn., *terminalis*, F. v. M., and perhaps others) and other Myrtaceæ, *Acacia* (*A. Simsii*, A. Cunn., *A. holosericea*, A. Cunn. and another), and Proteaceæ. The character of the savannas on the Fly River is almost, or quite, identical with the character of York Peninsula, the northernmost point of which is only about 100 miles distant from the mouth of the Fly River, but this is the only part of Papua in which strong affinities to the flora of Australia are shown. It seems strange that the Australian flora has not taken greater possession of New Guinea, but it would appear that collections show that Australian plants are strangers in Papua, the types of the flora being South Asiatic, Australian plants being very scantily sprinkled in Papua with the single exception of the Fly River savannas. This statement is made with some reservation, on account of the incompleteness of the data.

Prof. Warburg remarks that if Papua were connected with Australia through the York Peninsula at one time, which is very probable, it must have been before the time that Eucalyptus became such a prominent feature in the flora of Australia. At the same time, Eucalyptus is common in the savannas of the Fly River

By far the majority of the genera of Papuan plants are those of the Malayan Archipelago, those genera which have the most species in the eastern part of Malaya having the most species in Papua; but it would be wrong to consider the flora of Papua identical with the flora of Malaya, the number of endemic genera and species being too great.

Epiphytic Rhododendrons are common in high elevations in German Papua, connecting the flora with the Himalaya; a *Rhododendron* is also found on the highest mountain in Queensland, the Bellenden-Ker Range. Prof. Warburg states that Rhododendrons, mostly beautifully large-flowered species, are common on the Papuan mountain ranges at high elevations, and that there are two Coniferæ (*Phyllocladus hypophylla* and *Libocedrus papuana*) both closely allied with species he met in mountain regions of Borneo. These genera are also found in New Zealand, the former genus being found in Tasmania also. Several species of *Quercus* (Oak) are found in high mountain regions in Papua, connecting the flora with the Himalaya; no *Quercus* has yet been found in Australia.

As far as is known of the floras of Papua, New Zealand, and the Melanesian Islands, endemism is greatest in Papua, though New Caledonia may be found to equal it when the flora is better known.

The following genera are recorded from the summit of the Bellenden-Ker (Queensland) Range :—

Hibbertia (Dilleniaceæ) ; *Melicope* (Rutaceæ) ; *Leptospermum*, *Myrtus*, *Rhodamnia* (Myrtaceæ) ; *Pentapanax* (Araliaceæ) ; *Scævola* (Goodeniaceæ) ; *Agapetes* (Vacciniaceæ) ; *Trochocarpa*, *Dracophyllum* (Epacrideæ) ; *Rhododendron* (Ericaceæ) ; *Orites* (Proteaceæ).

The only genera of special interest to the student of the Papuan flora are *Agapetes* and *Rhododendron*. *Agapetes* is closely allied to *Vaccinium*; it contains about 30 species, chiefly from the southern Himalaya, and a small number from Fiji, Borneo, and Papua ; the two species from Papua have been found at high elevations on the Mount Owen Stanley Range *Rhododendron* has been already alluded to. *Dracophyllum* is so far interesting in that it connects the Bellenden-Ker flora with the Antarctic ; the genus is common in the Antarctic Islands and Tasmania, while one species is found in New South Wales, in Lord Howe Island, in New Zealand, and New Caledonia, being found chiefly in mountainous regions. It is not found in Papua, as far as the author knows, nor in Malaya and Asia.

Bentham* remarks that an exchange has evidently taken place in plants not strictly maritime between north-eastern Australia and New Caledonia and other islands of the South Pacific, but not to any great extent. More Australian types appear to be represented in New Caledonia than New Caledonian ones in Australia.

(c) The Antarctic Element (so called).

Hooker,† following Forster, used the expression "Antarctic plants of Australia," which are not so called because they really inhabit the country of that name beyond the polar circle, but because, in a botanical point of view, no less in a position relative to the south temperate flora, they represent the Arctic flora. He adds that they might indeed almost be called alpine plants, for many, which are found at the level of the sea in the so-called Antarctic islands, also ascend the mountains of more genial latitudes. Bentham‡ then speaks of the connexion of the alpine flora of Tasmania, Victoria, and New South Wales with the general southern extra-tropical and mountain region, extending through New Zealand to the southern end of the American continent and thence up the Andes. Many of the Australian species of this type are identical with or closely representative of New Zealand ones, and some have a much wider range. He adds that it is probably through this connexion that a few species belonging to the temperate or cooler floras of the northern hemisphere have evidently, in very remote times, become represented in Australia.

Hooker noted the following genera as most characteristic of the Antarctic regions :—*Colobanthus*, *Acæna*, *Donatia*, *Astelia*, *Forstera*, *Leptinella* (*Cotula*), *Ourisia*, *Drapetes*, *Fagus*, *Oreobolus*, *Lomatia*, *Carpha*.

Hemsley§ discusses the Antarctic flora, and using the plants enumerated by Engler,‖ adds very extensively to the list given by Hooker, and makes interesting deductions.

* Pref. to B. Fl. VII.
† "Introd. Essay to Flora of Tasmania," p. LXXXIX.
‡ Pref. to B. Fl. VII.
§ "Introd. to Rep. on Insular Floras" (*Challenger Rep. Bot.*, I. 50).
‖ Versuch einer Entwicklungsgeschichte der Pflanzenwelt.

The tabular view of the distribution of the Phanerogams of the islands south of New Zealand by T. F. Cheeseman.* together with the notes on the affinities of the flora, are most suggestive. See also valuable botanical contributions by Dr. L. Cockayne. R. M. Laing. and D. Petrie in the same work, to which I can only invite the attention of workers in this condensed sketch.

These Antarctic representatives are chiefly to be found in Tasmania; the Tasmanian flora has a surprising number of plants in common with the flora of the Australian Alps of Victoria and New South Wales, but the genera represented in northern New South Wales (*e.g.*, *Fagus*) and Queensland (*e.g.*, a *Dracophyllum* on Mt. Bellender-Ker) are much fewer, as are also those of Kangaroo Island and South Australia.

12. Affinities with the South African Flora.

The flora of South Africa and Australia have a great many species in common, but hardly any that are confined to the two regions; all, or nearly all, the species found in South Africa and in Australia are cosmopolitan plants, or plants of a wide geographical distribution, therefore without any value in regard to the development of the flora. Even the genera the two countries have in common are not numerous. Still there are many affinities between them, but the connexion that once probably existed, *viâ* the Antarctic, must have been separated so long ago that their common ancestors had time to develop into distinct species and genera. For instance: Australia has 34 genera of Proteaceæ, mostly endemic, but some are also found in New Zealand, New Caledonia, and Malaya. South Africa has eleven genera, mostly endemic. Not a single genus of Proteaceæ is common to Australia and South Africa.

Hooker points out that by far the greater number of the known species of Proteaceæ and Restiaceæ are confined to these two countries. Of our Australian Restiaceæ, the genera *Restio*, *Leptocarpus*, and *Hypolæna* are common to both.

The enormous time that must have passed since the separation of the two floras by some geological changes is still better expressed by the Epacrideæ and Ericaceæ. The common ancestors of the two families probably lived in both continents, and, as in Proteaceæ, the descendants developed along different lines; for some reason genera with anthers opening in terminal pores (Ericaceæ) prevailed in South Africa, and genera with anthers opening in parallel slits prevailed in Australia (Epacrideæ). The same characteristic goes through most families, though it is most pronounced in Proteaceæ, Epacrideæ, and Ericaceæ.

Bentham† discusses the connexions of the Australian and South African floras from the point of view of Compositæ.

Setting aside the cosmopolitan genera *Senecio* and *Gnaphalium*, the following genera are common to the two regions:—

Brachycome	..	41 Australian,		1 South African sp.	
Helipterum	..	53	..	12	..
Helichrysum	..	70	..	137	..
Cassinia	..	13	..	1	..
Athrixia	..	7	..	6	..
Cotula	..	8	..	22	,,

* "Sub-antarctic Islands of New Zealand" ed. Dr. C. Chilton, Vol. II., Systematic Botany, p. 389.
† *Journ. Linn Soc.* XIII., 552

Bolus and Woolley-Dod* remark that the following families, characteristic of Australian vegetation, abound most, after Australia, in South Africa, viz., Thymelaceæ, Hæmodoraceæ, Droseraceæ; and another point of approach is found in the remarkable deficiency in both countries of the widely diffused families Rubiaceæ, Lauraceæ, Araceæ.

Hooker, who first discussed the subject,† offered the hypothesis of a common origin of the Australian and South West African flora, derived from ancestors inhabiting a vast Antarctic continent of which the greater part has been submerged. He thought Western Australia was connected with the Cape district by land at a time when it was severed from eastern Australia. In this connexion, Moseley‡ asks how it is that marsupials are not found at the Cape, being nevertheless found in the Great Oolite in England? It would seem necessary almost that they must have been present at the Cape and have died out, unless it is possible that Proteaceæ and Restiaceæ are very much older than marsupials, in which case they would have been very old indeed.

13. The Australian Flora as a Whole.

Australia has three grand types of flora—the brilliant inflorescences of the dry sandy plains of Western Australia; the luxurious vegetation of eastern Queensland and New South Wales and the alpine plants of Tasmania. South Australia, the north-west of Victoria, and the vast western plains of New South Wales and Queensland approximate to the botanical conditions of the western State. Many Tasmanian or allied plants extend to south-eastern Australia generally, viz., most of Victoria and the south-eastern portion of New South Wales, the flora of Victoria being intermediate in character. The rain forests of western Tasmania are unique, and on the mainland are most closely approached by those of the Cape Otway district of Victoria.

Bentham remarks that maritime plants, ranging at least from the Mascarene Islands to those of the Pacific, are also to be found on the Australian coasts, mostly in identical species, with the addition of a few representative ones.

The following families are entirely confined to Australia or almost so, *e.g.*, Tremandreæ, Stackhousiaceæ, Candolleaceæ, Goodeniaceæ, Casuarinaceæ, Philhydreæ, together with the phyllodineous Acacias, which form an enormous majority of the genus, and Eucalyptus.

It is sometimes stated that the Australian flora is of a primitive character, but Moore strongly asserts that this is the result of bias imparted by the zoological data. "In what respect, it may be asked, is the flora of Australia less highly specialized? Are not most of the great natural orders strong constituents of it—trees, some of them of gigantic size, shrubs, undershrubs, and herbs, parasites and saprophytes, climbing and carnivorous species, flowers adapted to profit by the visits of insects, and sometimes provided with a complex mechanism to insure such profit all these are met with in Australia. In addition, the adaptability to the dry climate is wonderful, and in this respect, taking into account the variety of ways in which the destructive effects of a scorching sun and parched soil are guarded

* *Trans. South Africa Philos. Soc.*, XIV., 229.
† *Op. cit.*, p. XCII.
‡ "Notes by a Naturalist" (Challenger), Chap. VI.

against, the Australian flora is without a parallel the world over. And if these be not evidences of high specialization, it is difficult to know where one must look for such."*

Reference will first be made to some families of wide Australian distribution, each State then being discussed in turn, and its physical features briefly described, with especial reference to the flora, and, finally, such families as are mainly represented in any particular State, will be enumerated under that State.

The RUTACEÆ are widely diffused in Australia, extending from the coast to the interior. The family mostly consists of floriferous shrubs, very decorative for gardens, and also including a number of trees, belonging to *Evodia*, *Acronychia*, and allied genera, chiefly found in the brushes of New South Wales and Queensland. The genus *Boronia* now consists of 72 species, and 44 of them are Western Australian, most of them being peculiar to that State, New South Wales coming next with 25. *Eriostemon*, as defined by Mueller, includes such genera as *Crowea*, *Phebalium*, *Asterolasia*, and *Microcybe*, and most botanists do not follow him in this. In this larger grouping we have a second genus of 72 species, and no genus of Rutaceæ is more evenly diffused throughout the continent. The genera *Nematolepis*, *Chorilæna*, *Diplolæna* are confined to Western Australia, while *Bosmbya*, *Pagetia*, *Glycosmis*, *Murraya*, *Clausena*, have not been found out of Queensland. *Acradenia* is purely Tasmanian.

The STACKHOUSIACEÆ form an almost entirely Australian family of herbs usually quite small, and with *Stackhousia* by far the most important genus. Twenty-two species have been described so far, well distributed throughout the States.

Of the RHAMNACEÆ, *Alphitonia excelsa*, Reiss., is a moderately abundant tree of the brushes of New South Wales and Queensland, with conspicuously pale undersides to the leaves and bluish black fruits with reddish-brown seeds embedded in a brown powdery substance, and a remarkable timber of a pale colour which, on exposure to the light, very gradually assumes a rich red tint. The really important genera are two, *Pomaderris* and *Cryptandra*, the latter including (according to Mueller) the genera *Trymalium*, *Spyridium*, and *Stenanthemum*. Bentham, however, disagrees with such inclusion. *Pomaderris* is more eastern than western, and the reverse is the case as regards *Cryptandra*; the former is especially well developed in Victoria and New South Wales.

SAPINDACEÆ are fairly well developed in Australia, and almost every species is endemic. The genus *Dodonæa* (Hopbushes) occurs in every State, and extends from the coast to the interior. Most of the species are shrubs, and the Pinnatæ section comprises many beautiful ones. The genera *Atalaya*, *Alectryon*, *Cupaniopsis*, &c (*Cupania*, *Nephelium*), are chiefly trees of the coastal brushes of Queensland and New South Wales; *Atalaya hemiglauca*, F. v. M., the Whitewood, is an important inland tree.

The LEGUMINOSÆ stands at the head of Australian families, with 1,276 species, and the number is steadily being added to. The family includes a very large number of species with ornamental flowers, which make gay the Australian bush.

* Spencer Moore, "Suggestions upon the origin of the Australian Flora." *Nat. Sci.* XV., 1899, p. 207.

In the section PAPILIONACEÆ the genera *Brachysema*, *Chorizema*, *Gastrolobium*, *Isotropis*, *Burtonia*, *Jacksonia*, *Sphærolobium*, *Latrobea*, *Eutaxia* are practically Western Australian, as are mainly so many other genera. The genera *Lamprolobium*, *Tephrosia*, *Desmodium*, *Cajanus*, *Rhynchosia*, *Flemingia*, belong to the other side of the continent. Not many trees are included in this section; one of them is the gorgeous *Erythrina vespertilio*, Benth., the Batswing Coral, with beautiful crimson flowers and cuneate leaves, and which is found in the warmer parts of the continent.

Of the section Cæsalpineæ the most important genus is *Cassia* (30 species), for the greater part yellow flowering, and mostly shrubs, an exception being the moderate-sized tree (*C. Brewsteri*, F. v. M.), which bears trusses of most beautiful colour varying from yellow to orange and red. Most of the species prefer the dry country, only a few being found on the coast.

The section Mimoseæ is almost entirely taken up with the genus *Acacia*, by far the largest genus in Australia, 412 species having been described to date. It is divided into two grand sections, the Phyllodineæ, the leaves mostly phyllodinous without leaflets, and the Bipinnatæ, with bipinnate leaves. The latter section has under 30 species, about 380 thus falling into the Phyllodineæ, which is almost entirely Australian, a few other species belonging to this section occurring in India, Malaysia, and the Pacific Islands.

Acacias are universally known in Australia as Wattle, or prefaced by adjectives, such as Silver, Golden, Black, Green; they also bear such names as Myall, Boree, Mulga, Brigalow, Cooba, Dead Finish, Gidgee, Hickory, Umbrella Bush, Wait-a-while and Yarran, some of which are distinctive for species. The wattle has been adopted as the unofficial floral emblem of Australia; it is represented on the national coat of arms and on postal notes; will be on postage stamps, and is used for decorative purposes in a variety of ways. The genus is found in every State, from the coast to the arid interior, in swamps and on the dry sides of mountains, by the banks of rivers, and on the dry plains. They vary in size from 3 or 4 inches in height; most are shrubs of a few feet, while many are small trees, and some may be trees of great size, *i.e.*, 100 or 150 feet. Some are of economic importance for tan-bark or timber.

The family HALORRHAGIDEÆ is mainly represented by the genus *Haloragis*, which is chiefly Australian, but a few species are also found in New Zealand, in eastern Asia, in South Africa, and extra-tropical South America. There are 36 Australian species, and Bentham states that one species extends to New Zealand and the island of Juan Fernandez, 2 to New Zealand and eastern Asia, 1 to New Zealand only, the remaining 32 being endemic. They are mostly herbs and small shrubs with not showy flowers.

The MYRTACEÆ come second in point of number of species, 816 having been described so far; the family includes two very large genera, *Eucalyptus*, with 230 species, and *Melaleuca*, with 112. These belong to the tribe Leptospermæ (capsular, and entirely or chiefly Australian). The tribe Chamælaucieæ has a dry, indehiscent one-seeded fruit, while the third tribe, the Myrteæ, has an indehiscent berry or drupe. The vast majority of plants belonging to the family are worthy of cultivation on account of the beauty of their flowers, or of the neatness of the foliage or the shapeliness of the tree or shrub, or for their timber or essential oil.

Tribe *Chamælaucieæ.*—It is of course quite impossible to be more than exceedingly brief with such an all-pervading family. *Darwinia, Calycothrix* (Fringed Myrtle), *Verticordia*, and *Lhotzkya* are almost exclusively Western Australian, though the first two are represented by very numerous individuals which extend to the eastern States. *Thryptomene*, though predominantly western, is more widely diffused in the other States than the remaining genera. All are shrubs. *Chamælaucium uncinatum*, Schau., the "Geraldton Wax-flower," of Western Australia, is a shrub with large persistent pink flowers, and is one of the best shrubs ever introduced into cultivation.

Tribe *Leptospermæ.*—The genus *Bæckia* is mostly Western Australian, the sections Oxymyrrhine and Babingtonia exclusively so. In New South Wales this genus is much less frequently met with, and particularly so as the Queensland and Victorian borders are approached. *Hypocalymma*, *Calothamnus*, and *Eremæa* are exclusively western, and *Beaufortia* just extends to the Northern Territory. *Agonis* is western, with two eastern species. The important genera *Leptospermum*, *Kunzea*, and *Melaleuca* (all called Teatrees, though often shrubs) are well diffused throughout the States, and *Callistemon* (one of the groups of plants called Bottle-brushes) is mainly eastern. The genus *Eucalyptus* will be referred to separately. The important genera *Tristania* (Brush Box), *Syncarpia* (Turpentine), *Backhousia* are notable if only from the fact that they are exclusively eastern, and mostly denizens of the brushes.

The genus *Eucalyptus*, which comprises about 230 species, comes second only to *Acacia* in point of number amongst Australian genera, but it is so widespread and so abundant, that it is doubtless the most numerous in individuals of any. It is easily recognised by the operculum of the flower-bud.

The vast majority of flowers of Eucalyptus have white or cream-coloured filaments; those with very showy crimson or scarlet or yellow filaments are mostly entirely confined to western and tropical Australia. In eastern Australia *E. sideroxylon*, A. Cunn., an Ironbark, very commonly has individual trees with pink or crimson filaments, while in a number of species such variation in coloration has also been observed but only rarely. In Western Australia there are *E. erythrocorys*, F. v. M., and *E. Preissiana*, Schauer, with bright yellow filaments, and *E. ficifolia*, F. v. M., *E. macrocarpa*, Hook., *E. pyriformis*, Turcz., *E. phœnicea*, F. v. M., and a few others have beautiful red filaments, while those of *E. miniata*, A. Cunn., are orange-coloured.

The formation of adventitious shoots or "suckers," as they are invariably called in Australia, is well known to most people in Europe because of the difference in their appearance and that of the normal foliage. In Australian forests the phenomenon is forced upon the average man to an extent quite unknown in Europe, partly because there is so much primæval forest, partly because the extensive destruction of forest for arable or pastoral land is a matter of every-day occurrence, and partly because the contrast between sucker-leaves and normal-leaves is, as a very general rule, greater than it is in Europe.

These suckers are the curse of the pastoralist, who destroys the trees by ringbarking, to be followed by clearing or not, and who, as a rule, treats every

species of Eucalyptus (the predominant arboreal vegetation) indiscriminately, and without regard for the season of the year. This empiricism often results in vigorous second growths. Of late years, some attention has been given, by the most intelligent land-owners, to physiological principles, the ringing being done when the tree is in full flush of leaves or in flower. The poisoning of trees by treating the ring surface by arsenic is being experimented upon in different parts of Australia.

The barks of Eucalyptus trees vary greatly, but, being so easily seen from a distance, afford a ready diagnostic aid to classification of groups and even determination of species. The variation being so very great, these field observations require care in application. The usual or most elementary kind of bark is the smooth one, called the "Gum," and more or less glaucous, and more or less thick; we find this bark from the sandy coastal flats to the bleak swamps and mountain areas and away to the arid interior, *e.g.*, White Gum (*E. hæmastoma*, Sm.), Red gum (*E. rostrata*, Schlecht.). In the interior this is the prevalent kind of bark, with more or less (generally not very much) blackish or hard scaly or flaky-fibrous bark at the butt. Often the roughness is mere bulls' wool. Barks with smooth surfaces (*e.g.*, Grey Gum, *E. punctata*, DC., *E. tereticornis*, Sm.), however, exfoliate, usually in patches, and the newly exposed surface later on becomes harder, and exfoliates in its turn. Thus there is constant renewal of the bark of a smooth tree always in progress. In this way the bark grows and provides for the gradually increasing diameter of the stem. In some cases the patches are long and the older bark contains more fibre, with sufficient tenacity to form long ribbons (*e.g.*, Ribbony Gums, *E. viminalis*, Labill.). These are commonly found in the cooler tablelands of the southern and eastern States, and, when rendered supple by the rain and blown about by a strong wind, they stand out like the arms of a semaphore.

There is also that form of bark which is scaly all over the trunk, a form usually associated with the so-called Bloodwoods, *e.g.*, *E. corymbosa*, Sm. (heavy red-kino producers), which are usually found in sterile sandstone areas from the coast to the interior.

The bark may develop along two directions, one, such as is found in the Stringybark, which has a thick fibrous covering, with the fibres set longitudinally; the other, as in the case of the Box or Apple-bark, in which the fibre may be more compact or felted (*e.g.*, *E. hemiphloia*, F. v. M., *E. Stuartiana*, F. v. M.). If the fibrous bark be thinner and looser, it is often termed Peppermint (*e.g.*, *E. piperita*, Sm., *E. amygdalina*, Labill.), and here there are transitions on the other hand, to the Ribbony Gums.

Then there is a very hard furrowed bark, often black from age, known as Ironbark, the evolution of which Augustus Oldfield many years ago attributed to the longitudinal cracking of the bark accompanied by the matting caused by the discharge of a large amount of astringent exudation.

Amongst the types briefly defined there are all sorts of intermediate forms. Nor is the nomenclature of the different kinds of trees uniform; for example, the term Box, arising primarily from a tough interlocked timber, is often applied to a timber of such a class irrespective as to whether it has the *E. hemiphloia*, F. v. M. (the original Australian Box), type of bark. It

may have an almost ribbony bark. Very few barks are entirely smooth, and these are inclined to be thick and juicy; the character of the bark is probably a protective adaption against bush-fires. As the tropics are approached, the tendency of all Eucalypts is to have a smooth bark, or with a little scaly bark at the butt.

The timbers as regards colour may be roughly divided into red, brown, and pale. Red timbers may be found both in the interior (*e.g.*, *E. rostrata*, Schlecht., *E. microtheca*, F. v. M., *E. salmonophloia*, F. v. M.), or in the comparatively well-watered coastal districts (*E. marginata*, Sm., *E. resinifera*, Sm., *E. saligna*, Sm.); but in the dry districts of eastern Western Australia the timber is nearly always cigar-brown in colour. The pale timber (*e.g.*, *E. pilularis*, Sm., *E. microcorys*, F. v. M., *E. gomphocephala*, DC.) is mainly found in well-watered districts.

Most timbers are more or less interlocked, the Ironbarks affording an extreme case, but a few are fissile, of which the Gippsland Mountain Ash (*E. regnans*, F. v. M.) is a type.

Mallee is the term formerly employed to denote shrubby Eucalypts with a thickened root-stock from which many stems spring; the term now often includes species without the thickened root-stock. Marlock is the Western Australian equivalent to Mallee, and includes all gum scrub on a sand-plain. Gum scrub species never (or very exceptionally) attain the dignity of a tree from which timber may be cut.

E. rostrata, Schlecht., is probably the most widely diffused of all species. It is moisture-loving, and follows the course of streams, or may be found in depressions in which, on the rare occasions on which rain does fall, it may find its way to the subjacent strata.

Tribe *Myrteæ*.—This group is entirely eastern, and with one solitary exception (*Eugenia Smithii*, Poir., the "Lilly Pilly"), which extends to Victoria, belongs to New South Wales and Queensland, and chiefly to the latter. With hardly an exception, the whole tribe is found in brushes, and the members of it usually go by the name of Myrtles, very much oftener than the remainder of the Myrtaceæ. *Eugenia* is by far the most important genus, and it includes a number of medium-sized or large trees, often planted for ornament, on account of their symmetry, the dainty colouring of their young foliage, the beauty of their abundant fruit, and the neatness of their (usually) white flowers. *Myrtus* is a beautiful and important genus of shrubs and trees, belonging even more to Queensland than to New South Wales. *Rhodomyrtus* is of less importance, while the handsome *Barringtonias* are mainly tropical.

UMBELLIFERÆ form a valuable constituent of the vegetation of Australia. *Hydrocotyle* is the largest genus (32 species), and all are endemic but two; it is widely diffused, but mainly Western Australian. *Didiscus* (26 species) is exclusively Australian and well diffused throughout the States. *Trachymene* (*Siebera*) is practically endemic, and has 30 Australian species, mainly western, but with a noticeable eastern (New South Wales and Queensland) representation. *Xanthosia* is an endemic genus of not specially ornamental herbs, mainly, but by no means exclusively, occurring in Western Australia. *Actinotus* is also endemic; New South Wales has 5, Western Australia 4, and Tasmania 3 species. *A. Helianthi*, Labill., is the well-known

"Flannel Flower" of New South Wales, and *A. rotundifolia*, DC., the "Southern Cross" of Western Australia.

The COMPOSITÆ take the fourth place in the flora of Australia, with 635 species. In the Flora Australiensis, Bentham gave the number at nearly 500, arranged under 88 genera, 39 (of which 18 were then monotypic) being endemic to Australia. I compute that there are at present 101 indigenous genera, 56 of which are endemic, and of these 25 monotypic.

The principal genera are *Aster*, 71 species; *Helichrysum*, 70; *Helipterum*, 51; *Brachycome*, 41; *Calotis*, 18; *Podolepis*, 17; *Angianthus*, 25; *Gnephosis*, 18; *Senecio*, 30.

It is not surprising, considering the facility (*e.g.*, by means of pappuses), with which so many species are distributed, that there is less local distribution of Composites than in any other large family.

Some species, *e.g.*, *Helichrysum*, *Helipterum*, *Waitzia*, *Cephalipterum* are cultivated as "Everlastings"; others, *e.g.*, *Aster*, *Humea*, *Ammobium*, *Senecio*, *Brachycome*, are herbs and shrubs capable of adorning the garden; while some are mere weeds.

The GOODENIACEÆ are almost entirely Australian. The family contains here 294 species, divided into *Goodenia*, 112; *Scævola*, 68; *Dampiera*, 54; *Leschenaultia*, 22; *Velleia*, 19; and representatives are to be found nearly all over the continent, *Goodenia* being most widely diffused. *Scævola* is found to a comparatively small extent near the coasts of other continents. The family is remarkable for a cup-shaped or two lipped dilatation at the top, called the *indusium*, and which encloses the stigma. The colour of the flowers of *Goodenia* and *Velleia* are yellow, *Scævola* generally purple, *Dampiera* blue, and *Leschenaultia*, the most brilliant blue it is possible to imagine, and because of the profusion of the flowers, a sight of *Leschenaultia* country in the spring is a memorable recollection.

Goodenia is, by majority, Western Australian (48), but there is a strong South Australian element (25), while Victoria has 10 species. Queensland (18) and Northern Australia (21) are even better represented. The genus has 16 species in New South Wales, nor is it absent from Tasmania (6). *Scævola* is mainly Western Australian, with a good sprinkling in the other States, and the same may be said of *Dampiera*. *Leschenaultia* is the heritage of the western State, no Western Australian representatives being found in the other States; two species are found in South Australia, one is found in Northern Australia, Queensland, and New South Wales, and two others in Northern Australia, of which one belongs also to Queensland.

The ERICACEÆ are but poorly represented, three species of *Gaultheria* being found in Tasmania, one of which extends to Victoria and New South Wales, while a *Pernettya* and a *Wittsteinia* occur in Tasmania and Victoria respectively. A *Rhododendron* and an *Agapetes* occur on the summit of Mount Bellenden-Ker, in Queensland.

But we have our compensation in the profusion of EPACRIDACEÆ, both as regards species (301) and individuals. The two grand divisions into Styphelieæ, with indehiscent, usually drupaceous fruit, and the Epacreæ, with loculicidally dehiscent capsule, are sharply defined. Taking the genus *Styphelia*, it is a question of one large genus (193 species at present) or a number of genera as defined by Robert Brown and others, and approved

by Bentham. It is admitted at once that these are species with intermediate characters, but the genera or sub-genera, to which I have referred, have mostly such characteristic facies that it seems regrettable to abandon them. The position is admirably summed up by Bentham in the *Flora Australiensis*, V., 145, and most field botanists will agree with him.

The genus *Leucopogon*, readily known by its small white flowers with bearded corolla lobes, has 133 species, and it is almost exclusively Australian. Most of the species are Western Australian, New South Wales coming next in order of number, but the genus is represented in all the States. The monotypic genera *Needhamia* and *Oligarrhena* are Western Australian, as are also the small genera *Coleanthera* and *Conostephium*, while *Melichrus* is east Australian.

The original genus *Styphelia* ("Five Corners") has eleven species, chiefly New South Wales and then Western Australian, while *Astroloma* is mainly Western Australian, with three species that extend to New South Wales. Space does not permit detailed reference to the remaining genera, except to say that when in fruit many of the shrubs look very beautiful, and that Tasmania is the State in which to see them at their best. Some of the Stypheliеæ in flower are very pretty.

The beauty of the section Epacreæ rests mainly in its flowers, and the genus *Epacris* (30 species) stands out pre-eminent in that respect. The genus is mostly east Australian, New South Wales having 19 species, although those of Tasmania and Victoria are glorious. Then there are the ornamental genera *Andersonia* (20 species) and *Sphenotoma* (6), both peculiar to Western Australia and allied to *Sprengelia*. The genera *Richea* (8) and *Dracophyllum* (4) are herbs or small shrubs with a monocotyledonous aspect, as pointed out by Bentham. They are mostly Tasmanian, and the genus *Richea* is there known as "Grass-tree." *R. Gunnii*, Hook., extends to the Australian Alps of Victoria and New South Wales. *Dracophyllum* is smaller (the giant *D. Fitzgeraldi*, F. v. M., occurs in Lord Howe Island); two species are Tasmanian, and New South Wales and Queensland have one each.

The SOLANACEÆ are chiefly represented in Australia by the genera *Solanum* (56 species), *Anthocercis*, 18; while the principal masticatory of the aborigines is *Duboisia Hopwoodii*, F. v. M., a shrub found only in the interior: there are three other species, two belonging to the brushes of the east coast. The genus *Solanum* is best developed in New South Wales and Queensland, but South Australia is well represented, and Western Australia only a little less. *Anthocercis* is endemic and differs only from *Duboisia* in having a capsular fruit. The genus is mainly Western Australian, but has many representatives in New South Wales and Victoria.

The MYOPORACEÆ form an almost entirely Australian family, the genus *Myoporum* being represented only to a small extent in the Indian Archipelago and the Pacific Islands, and by one species in tropical Africa. One Australian species (*M. tenuifolium*, G. Forst.) extends to New Caledonia. There are in all fifteen species, and they are well distributed throughout the States. *M. platycarpum*, R. Br., the "Sugar Tree," which often exudes a saccharine substance, being a well-known tree of the interior.

But the glory of the family is the genus *Eremophila* (including *Pholidia*), of which there are no less than 91 species. They are mainly Western and

South Australian, with a very strong New South Wales contingent. From the other States (except Tasmania) they are by no means absent. They are essentially dry country species, and are mostly of an ornamental character, bearing a profusion of flowers, varied and dainty in tint, but the colour is unfortunately lost in drying. They are shrubs varying in size.

The VERBENACEÆ will be found very interesting. The whole of the genera of the Chloantheæ are endemic. Of the other sections the Lantana (*L. Camara*, L.) is an introduced species, and its aggressiveness has caused great devastation in eastern New South Wales and Queensland. *Gmelina* has three species, and includes *G. Leichhardtii*, F. v. M., a beautiful tree of the brushes of New South Wales and Queensland, which yields the especially valuable timber known as "Native Beech." *Avicennia officinalis*, L., widely distributed in other parts of the world, is known here as "White Mangrove," and encircles the Australian coast; it is absent from Tasmania.

Of the endemic genera, *Lachnostachys* is confined to Western Australia, and its nine species are more or less densely hairy, which has obtained for them the name of "Blanket Plants." *Newcastlia* is also a woolly genus with six Western and five South Australian species. *Physopsis* and *Mallophora* are closely allied genera, alike woolly and western. *Dicrastylis* is an allied genus of six Western and five South Australian species, and two have recently been described from Queensland.

The most important genus is *Chloanthes* (including *Pityrodia*, the amalgamation of which is not concurred in by all botanists), which now comprise 26 species almost exclusively Western Australian, only one extending to Victoria, 2 to New South Wales, 2 to Queensland, and 4 to northern Australia. *Hemiphora* and *Denisonia* are monotypic, the former from Western and the latter from Northern Australia. *Cyanostegia* has two species from Western and one from Northern Australia.

Of the LABIATÆ, the genera of the well-marked tribe Prostanthereæ are alone endemic of the five genera which compose it. *Prostanthera* is by far the most important (50 species), followed by *Hemigenia* (including *Hemiandra*), 37; *Microcorys*, 16; and *Westringia*, 10. As regards *Prostanthera*, the preponderance of species (33) is in New South Wales, but there is a strong Victorian and South Australian element, only seven species occurring in Western Australia. With the prevailing colour of the flowers purple or purplish, some of the species are singularly floriferous and beautiful, and would adorn any garden. The lovely *P. Sieberi*, Benth., of eastern New South Wales, and *P. lasianthos*, Labill., "Mint Bush," a tall shrub which lines water-courses in most of the States, may be cited.

Hemigenia is mainly Western Australian, though New South Wales and Queensland each have two species. *Microcorys* is Western Australian except as regards one species, which spreads into South Australia. *Westringia* is more evenly distributed, Western and South Australia each having 3 species; Tasmania, 4; Queensland, 5; Victoria and New South Wales, 6.

The family CHENOPODIACEÆ is so widely diffused, and of such high economic importance to pastoralists, that we are apt to look upon it as more Australian than it really is. Some of the principal genera are not endemic in Australia, *e.g.*, *Chenopodium*, *Atriplex*, *Kochia*, but they are richly represented by endemic species, while the number of individuals is legion. "Salt

bush" being the characteristic vegetation of enormous areas. While the genera are well distributed throughout the States, they are indicative of salinity, and are most commonly found in regions of low rainfall or in proximity to the sea. *Atriplex* is represented by 32 species; *Rhagodia*, 13; *Chenopodium*, 11: *Kochia* (Cotton-bush), 30; *Bassia*, 37.

The genus *Ptilotus* (*Trichinium*) is an extensive and purely Australian genus (76 species) of AMARANTACEÆ usually, but not exclusively, occurring in regions of low rainfall. The flowers are in dense cylindroid spikes, usually pink, purple, or yellowish, and often known as "Silky-heads." The individuals are often gregarious, covering large areas with a bright colouring.

The PROTEACEÆ form the third in order of abundance of species in Australia, having 667 distributed over 34 genera, some of the principal being *Grevillea* (193), *Hakea* (107), *Persoonia* (62), *Dryandra* (49), *Banksia* (48). Australia is the chief seat of the family, although it is well represented in South Africa. Every tribe is represented in Australia.

The distribution of the species within the States is as follows:—Western Australia is far ahead of any other State with 431; then follow in order New South Wales, 137; Queensland, 96; Victoria, 58; South Australia, 41; North Australia, 36; Tasmania, 23.

Very few genera do not occur in Western Australia, while *Adenanthos*, *Simsia*, *Synaphia*, and *Dryandra* are found there alone; the monotypic genera *Bellendena*, *Agastachys*, and *Cenarrhenes* are confined to Tasmania; *Symphonema* occurs only in New South Wales; the monotypic genera *Roupala*, *Musgravia*, *Carnarvonia*, *Buckinghamia*, *Darlingia*, *Cardwellia* in Queensland, together with *Hollandiæa* (two species). *Hicksbeachia*, *Helicia*, *Macadamia*, *Strangea*, *Stenocarpus*, *Embothrium* are confined to the brushes of New South Wales and Queensland.

The genera *Isopogon*, *Persoonia*, *Grevillea*, *Hakea*, *Banksia* occur in every State, while *Grevillea* and *Persoonia* are the only genera in which any State has more species than Western Australia; the numbers being *Grevillea*—New South Wales, 77; Western Australia, 70; and *Persoonia*—New South Wales, 32; and Western Australia, 25. *Lambertia* shows the peculiar distribution of Western Australia, 7; and New South Wales, 1.

The copious woodiness of the follicle is observed in many genera of Proteaceæ, *e.g.*, *Hakea* and *Xylomelum*; in the latter genus it is so pronounced as to earn for it the name of "Wooden Pear"; this protection to the seeds is doubtless a protective adaption in view of the frequent burning off which falls to the lot of Proteaceous shrubs.

It is only in the brushes of New South Wales and Queensland that the Proteaceæ attain their largest development, *Macadamia ternifolia*, F. v. M. (yielding an excellent edible nut); *Orites excelsa*, R. Br., and *Grevillea robusta*, A. Cunn (both "Silky Oaks"); *Stenocarpus sinuatus*, Endl. (the "Fire-tree") and *S. salignus*, R. Br. (Red Silky Oak); *Embothrium Wickhami*, Hill and F. v. M.; *Buckinghamia celsissima*, F. v. M., *Cardwellia sublimis*, F. v. M., and a few others attaining the magnitude of first-class trees.

Hundreds of species of Proteaceæ are well worthy of cultivation. Amongst the very great number of beautiful shrubs, the gorgeous *Telopea speciosissima*, R Br., or "Waratah," stands pre-eminent. Of the trees, *Grevillea robusta*, A. Cunn., and *Stenocarpus sinuatus*, Endl., are, perhaps, oftenest seen in

gardens, but there is a wonderful and beautiful collection to choose from. Many of the shrubs have charming "cut leaved" foliage, and are worthy of attention for that characteristic alone. Many of the *Banksias* ("Bottle-brushes") and *Dryandras* are delightful plants, often bizarre. In Western Australia some species of *Conospermum, e.g., C. stœchadis*, Endl., and *C. floribundum*, Benth. (Dwarf Smoke Bush), have such a copious tomentose white or greyish inflorescence as to give the appearance of smoking bushes, and in some districts they are in such abundance, to the local exclusion of almost every herbage, as to remind one of a heavy snow-fall, just thawing so as to show a little of the other herbage.

The THYMELACEÆ are almost exclusively represented by the Australian genus *Pimelea*, of which we have 76 species, fairly well distributed throughout the States, with the exception of the sections *Heterolæna* and *Calyptrostegia* (sub-section *Calyptridium*), which are all confined to Western Australia. They are usually small plants and not particularly ornamental, but some may be classed as such, expecially the showy Queensland *P. hæmatostachya*, F. v. M. The bark of all is fibrous and very tough, and that obtained from the larger species was formerly used by the aborigines for making their little bags.

Turning to the SANTALACEÆ, *Exocarpus* includes the "Native Cherry," which has won so much renown through having "the stone outside the fruit." *E. cupressiformis*, Labill., being the best known. The genus is widely distributed throughout Australia. It is root-parasitic like so many of its congeners, the family in this respect, as well as in floral characters, showing close affinity to the Loranthaceæ. *Leptomeria* ("Native Currant") and *Choretrum* are genera of erect leafless shrubs, the former more western and the latter more eastern in its distribution. The genus of most economic importance is *Santalum*, and includes species which furnish the Sandalwood of India and Polynesia. *S. cygnorum*, Miq., is the small tree which yields the Sandalwood of Western Australia, which has hitherto defied all attempts at reproduction on a commercial scale. It is in such demand that it is pulled up by the roots wherever seen, and visitors will observe pale-coloured, irregularly-shaped stems of it a few inches in diameter on trucks on the railways and on the wharf at Fremantle, for export to Singapore. The well-known Quandong is *Fusanus acuminatus*, R. Br. Both genera extend to eastern Australia, but they are essentially plants of low rainfall.

The CASUARINACEÆ, universally known as Oaks or She-oaks in Australia, consists of 29 species. Thirteen of them are confined to Western Australia, some are widely diffused, while a few are mostly eastern. Some are shrubs; in the dry country there are trees of medium size; in eastern Australia some species become very large. They occur in the desert, in dry rocky country, in saline soils both near the coast and inland, and the largest trees, River Oak (*C. Cunninghamiana*, Miq.), mark the courses of our eastern rivers.

The family TAXACEÆ has five genera, *Podocarpus* (*Nageia*), *Pherosphæra*, *Microcachrys*, *Dacrydium*, and *Phyllocladus*. This family chiefly occurs in Tasmania, the Australian representatives of the genera *Microcachrys*, *Dacrydium*, and *Phyllocladus* being confined to that State. *M. tetragona*, Hook. f., is a small creeping wiry shrub, confined to mountain-tops; *D. Franklinii*, Hook. f., a tall tree known as the "Huon Pine," found in the

south-west, and *P. rhomboidalis*, Rich., the "Celery Top Pine," is common on mountains chiefly to the south and west (of Tasmania).

The genus *Phærophæra* has two species, both shrubs. *P. Hookeriana*, Archer, found in Tasmania on the tops of mountains, and *P. Fitzgeraldi*, F. v. M., in a few localities in the higher parts of the Blue Mountains, New South Wales.

The genus *Podocarpus*, called "Damsons" by the boys because of the enlarged succulent peduncle, comprises six species found in Australia, although the genus also occurs in South America and Eastern Asia. Five of our species are endemic, while one extends to Malaya. *P. elata*, R. Br., is the "She or Brown Pine," a large tree of New South Wales and Queensland, and *P. Ladei*, Bail., the so-called "Mt. Sturgeon Black Pine," is also a large tree, and occurs in northern Queensland. *P. spinulosa*, R. Br., is a bulky shrub of eastern New South Wales, and *P. alpina*, R. Br., is a straggling appressed shrub found on mountain tops in Tasmania and the Australian Alps. *P. Drouyniana*, F. v. M., is the only species found in Western Australia; it grows in the south-west, and is looked upon as an indication of poor sandy land. It grows in dense clumps 3 ft. 6 in. in diameter, and bears the local name of "Emu-berry."

Of the family PINACEÆ there are two handsome Kauri Pines. *Agathis* (*Dammara*) *robusta*, C. Moore, and *A. Palmerstoni*, F. v. M., both peculiar to coastal Queensland. The genus *Araucaria* has also two fine commercial trees, viz., *A. Cunninghamii*, Ait., the "Hoop or White Pine," of the brush forests of northern New South Wales and Queensland, and *A. Bidwilli*, Hook. f., the "Bunya Bunya," peculiar to southern Queensland, and bearing cones as large as a child's head, which furnish the large seeds used as food by the aborigines. *A. excelsa*, R. Br., so often seen planted in Australia, is the "Norfolk Island Pine," and is not indigenous to Australia. Adventitious leaf or branch buds in the form of woody nodules, and which are really abortive branches, are found in the bark of some trees, particularly those of certain *Araucarias*.

Arthrotaxis is confined to Tasmania, where there are three species found in the western mountains. All are small or medium-sized trees, valued, like all the Pinaceæ, for their timber. *A. cupressoides*, D. Don, is the original "King William Pine," a designation now also often given to *A. selaginoides*, D. Don; the third species is *A. laxifolia*, Hook. f., and all three are sometimes called "Red Pine," because of the colour of the timber.

The genus *Callitris* is the most abundant pine in Australia. It contains fifteen species, and is found from Tasmania to the tropics, and from the sea coast to the arid interior. Sometimes these trees, called "Cypress Pine," are so abundant as to be looked upon as a pest. They are usually beautiful trees, sometimes bright-green, and sometimes glaucous, and the species are largely determined on the shape of the cone. They chiefly occur in New South Wales and Queensland, but are common in Western Australia.

Fitzroya has two species, one confined to Tasmania, the other to temperate South America. The Tasmanian species, *F. Archeri*, Benth. and Hook. f., is a small shrub, and is found on mountain tops in the southern part of the island.

The CYCADACEÆ are represented in Australia by three genera, *Macrozamia*, *Cycas*, and *Bowenia*. The first is by far the most abundant, and is chiefly developed in eastern New South Wales and Queensland, and, to a less extent, in south-western Australia. There are sixteen species, *M. spiralis*, Miq., occurring extensively both in southern and northern New South Wales; a number of forms, *M. Fawcetti*, *heteromera*, *cylindrica*, *secunda*, *flexuosa*, all named by C. Moore, were first brought under notice as horticultural varieties, but I look upon them as good species. All are less robust than *M. spiralis*. *M. Perowskiana*, Miq., is a taller species, and occurs in northern New South Wales and southern Queensland, while *M. Moorei*, F. v. M., of Springsure, Queensland, is a larger species. *M. Hopei*, W. Hill, of north Queensland, is the largest of all, and is stated to attain a height of 60 feet *M. Miquelli*, F. v. M., extends from near Brisbane to Rockhampton, Queensland, but *M. platyrachis*, Bail., *M. Paulo-Gulielmi*, F. v. M. (an especially graceful species), *M. Mountperriensis*, Bail., *M. Douglasi*, Hill and F. v. M., are more restricted in their habitats. *M. Macdonnelli*, F. v. M., is found in the Macdonnell Ranges of northern South Australia, technically in the Northern Territory, while *M. Fraseri*, Miq., and *M. Dyeri*, F. v. M., are peculiar to Western Australia. *Macrozamias* in New South Wales go under the name of "Burrawang."

The four species of *Cycas* are confined to northern Queensland, and our two species of *Bowenia*, *B. spectabilis*, Hook., and *B. serrulata* (André), Chamb., have a somewhat similar range. All our Cycads, apart from their very great botanical interest, are of special horticultural value.

The interest of the small family AMARYLLIDEÆ (26 Australian species) will be in four out of its seven genera, *Doryanthes*, *Crinum*, *Calostemma*, and *Eurycles*.

Of *Doryanthes* we have two species, *D. excelsa*, Correa, and *D. Palmeri*, W. Hill; both are very large plants, with large sword-shaped leaves and with very tall flowering stems and massive inflorescence. The former is from coastal New South Wales and Queensland; the latter, which is somewhat variable, is confined to southern Queensland. The flowers are crimson in colour. Our *Crinums* are eleven in number, all found in Queensland, and several extending to northern Australia. One also occurs in New South Wales, as does also a small and beautiful species (*C. flaccidum*, Herb.), which is found in the interior of all the States except Tasmania. The two species of *Calostemma*, *C. purpureum*, R. Br., and *C. luteum*, Sims, are also from the drier country. *Eurycles Cunninghamii*, Ait., is found in north coastal New South Wales and coastal Queensland; *E. amboinensis*, Loud., occurs in Queensland and northern Australia, and extends to the Indian Archipelago.

The Australian LILIACEÆ amount to 189 species in 15 genera. Only some of the more prominent genera can be taken notice of. *Blandfordia* known as "Christmas Bells," comprises four species, three of which are found in coastal New South Wales, one extending to Queensland, while one is confined to Tasmania. The flowers are reddish or reddish-brown or yellow, and very ornamental.

Thysanotus is the "Fringed Violet," because the flowers are of a violet colour, and fringed at the edges. They are small plants, with grass-like

leaves. There are 21 species, of which fourteen are found in Western Australia. South Australia has six, and Victoria and New South Wales four each.

The genus *Xerotes* consists of 37 species, rush-like plants, with small flowers usually dull-yellow, dioecious. *Xanthorrhœas* are the "grass trees" of eastern Australia, the "Black-boys" of Western Australia, and the "Yuccas" of Kangaroo Island and part of South Australia. They have usually a caudex, showing the charred bases of the grass-like leaves, which form a tuft at the top. Each caudex is surmounted by a spear-like flowering spike. They exude a yellowish or reddish resin which was formerly known as "Gum accroides," and now as "Grass-tree Gum" or "Black-boy Gum." There are 13 species, only 2 being found in Western Australia, while 5 are found in South Australia, including 1. *X. Thorntoni*, Tate, in the Macdonnell Ranges. Two species are found in Tasmania, 3 in Victoria, 4 in Queensland (including the tiny *X. pumilio*, R. Br., from Port Curtis), and 5 in New South Wales.

The monotypic genus *Kingia* (*australis*, R. Br.) reminds one a good deal of a *Xanthorrhœa* with a long caudex, but it has several scapes, and the flowers are arranged in a globular terminal head so that it becomes a many-headed grass tree. It is accordingly known as "Drum-head Grass-tree," and because of the silvery appearance of its foliage "Silver-leaf Grass-tree." It is often a conspicuous feature of the landscape from Albany to Perth, Western Australia.

CYPERACEÆ are well developed in Australia, numbering 421 species so far. The cosmopolitan genus *Cyperus* is strongly developed (72 species) and well diffused in Australia, with predominance in Queensland and New South Wales, but most species are non-endemic. *Schœnus* is even more largely represented (77 species), and is widely diffused, with, however, a strong Western Australian preponderance. All Australian genera of Cyperaceæ are more or less common, with the exception of a few of the small ones. *Fimbristylis*, with its 58 species, is chiefly North Australian and then Queensland. Of the remaining genera the principal, *Heleocharis* (13), *Scirpus* (26), *Carex* (43), are alike well diffused in Australia and in other parts of the world. *Scleria* (13) is chiefly Queensland and northern Australia, and *Lepidosperma* (36) and *Gahnia* (29) are characteristic constituents of the vegetation; the former genus is almost endemic, while species of the latter freely occur in New Zealand.

Of GRAMINEÆ, 433 species have been described to date, and, as with so many of our families, many additional ones will doubtless be brought under notice. From the economic point of view they are very important, for they are the stand-by of the countless flocks and herds of this continent. It is not possible to do justice to them in a brief sketch, nor is it possible to refer to the rich crop of aliens, purposely or accidentally introduced. There are 78 indigenous genera; but only fourteen, comparatively small, are endemic. Many of the species are endemic, and, taking them as a whole, the species are well diffused throughout the States.

Of *Panicum* there are 75 species; they are useful almost without exception. The long trailing *Spinifex* is not to be confused with the "Spinifex" of bushmen, which is the name given to *Triodia*, mostly dense, hummocky, prickly species of the dry country. *Neurachne* is "Mulga Grass," because

it is often found under Mulga (*Acacia aneura*. F. v. M.). Of *Andropogon* we have 27 species, including some of the best fodder plants, such as "Blue Grass," *e.g.*, *A. sericeus*, R. Br., and its allies. *Anthistiria ciliata*, L. f., is the well-known "Kangaroo Grass," *A. membranacea*, Lindl., "Flinders Grass," while *A. imberbis*, Retz., is called "Bundle Bundle" in Western Australia. *Aristida* with its characteristic trifid awn, has ten species, and is often called "Wire Grass." The inflorescence of *Stipa* is sometimes elegantly plumose (particularly *S. elegantissima*. Labill.), while the hardened tip of the flowering glume enclosing the grain, bores, aided by the twisted awn, into the flesh of animals, and hence they are called "Spear Grasses." Certain species become obnoxious to the pastoralist, but all yield useful feed when young.

Only eight species of *Danthonia* are found, but *D. penicillata*, F. v. M., the widely diffused "Silver Grass," or "Wallaby Grass," is one of the best of fodder grasses, and *D. robusta*, F. v. M., a coarse species, is the best fattening grass on the Mount Kosciusko Plateau. *Astrebla* is a small genus, but its triticoid species are valuable dry-country grasses and are called "Mitchell Grasses." *Cynodon dactylon*, L. C. Rich., is the "Couch Grass" of coastal New South Wales and Queensland, one of our most valuable grasses for pastures and for lawns; it is identical with the "Doub" of India and the "Bermuda Grass" of the United States.

There are thirteen species of *Poa*, some harsh and some succulent fodder grasses. The introduced *P. annua*, L., is complementary to *Cynodon dactylon*, since it takes its place every winter. *Eragrostis* claims 28 species, some with an ornamental inflorescence, some capable of great drought resistance, even bulbous, and all more or less valuable for sheep.

Two species of *Bambusa* (Bamboo) are found, one in Queensland, and the other in north Australia.

Stenotaphrum americanum, Sch., is an American grass acclimatised in the coastal districts, and invariably known as "Buffalo Grass," from the circumstance that, in the very early days, it was first observed near Sydney after the visit of an American ship *The Buffalo*. It is, however, not to be confused with the grass known in America as Buffalo (*Bouteloua*).

The Brazilian *Paspalum dilatatum*, Poir., and the South African *Chloris Gayana*, Kunth, have proved themselves valuable fodder grasses for dairy cattle. *Ammophila arundinacea*, Host., "Marram Grass," has, particularly in southern Victoria, proved an admirable sand-stay.

14. The Flora of the Individual States.

(a) Western Australia.

Western Australia is the largest State of the Commonwealth, practically comprising the western third of it. It contains many varieties of soils, light and sandy prevailing. The south-western portion is the best watered, and here the chief timber-wealth is to be found.

The northern portion of the State approaches the tropics, and has many plants in common with the Northern Territory, which adjoins it. It is not remarkable for the height of its mountains but all of its mountain country is full of interest to the botanist. For example, the Kimberley country is much indented by fiords; it is also mountainous, consisting of alternating high

and lower lying plateaux, the highest country being principally sandstone. In this district we have the Princess May Range, south-east from York Sound, and probably reaching an altitude of over 3,000 feet, while the King Leopold Range, south-east from Collier Bay, although attaining a little less elevation, also promises rich rewards to the botanical investigator.

In the Hammersley Range in the north-western district (much of which is mountainous), and between the Fortescue and the Ashburton Rivers, is Mt. Bruce (3,800 feet), reputed to be the highest point in the State.

In the south-west district, the important range is the Darling, running nearly due north and south from Yatheroo, in the north, to Point D'Entrecasteaux, on the south coast. This range lies parallel to and from 18–20 miles distant from the western sea-board, and is the most important range in the State by reason of its effect on the climatic conditions of the most closely settled areas. The highest point, Mt. William, in the Murray district, is 1,700 feet.

Stirling Range, 40 miles north-east of Albany, the loftiest range in the southern portion of the State, is perfectly isolated and, rising abruptly from a low-lying coastal plain, is visible for a great distance. Mt. Tulbrunup, over 3,000 feet, is the highest peak, and the whole range is of fascinating interest to the botanist.

A large proportion of the south-west and south sea-boards, is of a flat and sandy character, with indications of a recent geological formation, and may be described as a vast forest, principally timbered with Jarrah (*Eucalyptus marginata*, Sm.), Red Gums (*E. calophylla*, R. Br.), Karri (*E. diversicolor*, F. v. M.). The Tuart (*E. gomphocephala*, DC.) is confined to the coastal limestone strip south of Perth, while further north is the beautiful yellow flowered *E. erythrocorys*, F. v. M.

In the south-west, not only is there a very good rainfall, but subterranean water is not far from the surface. The Esperance district on the south coast has an especially rich flora. In the drier parts, Western Australia is remarkable for the number and extent of its salt lakes, which support a true saline flora. They often give the impression of a mirage.

Between the 30th parallel of latitude and of the Great Australian Bight, much of the country is of limestone formation, and here there are immense areas of grassland which only wait the discovery of subterranean water to make them amongst the most productive areas of the State. The author is indebted for most of his notes on the physical features to the report of Mr. F. S. Brockman in Fraser's *Year-book of Western Australia.*

No considerable portion of the interior lying between the 19th and 31st parallels of latitude, and between 121st and 129th meridians of longitude, is suitable for any class of settlement except in connexion with mineral resources (chiefly gold). This area may be described as a great tableland with an altitude of 1,000–2,000 feet above sea-level, the surface of which consists largely of sand-dunes, though in many parts of it there are large areas of clayey soils. It would be a contradiction of terms to call it desert, for it supports a copious and beautiful flora.

Mr. Henry Deane says that the soil of the country from Kalgoorlie, in Western Australia, to Spencer's Gulf, in South Australia, is for the most part

good, and covered with vegetation consisting of various saltbushes (*Atriplex*), blue bush (*Kochia*, etc.), grass, and other shrubs, mostly edible, and trees of various kinds, such as Mulga (*Acacia aneura*, F. v. M.), Myall (*A. pendula*, A. Cunn.), Mallee (*Eucalyptus oleosa, uncinata*, etc.), and *Myoporum*, with frequent bushes of Sandalwood (*Santalum cygnorum*. Miq.), and Quandong (*Fusanus acuminatus*. R. Br.).

In the western State, one will hear much of the term "sand-plain," and it is wonderful how these light sandy areas, usually devoid of trees, maintain very gardens of flowers.

The physical features (mountains chiefly) have been referred to in a little detail, as they are of especial interest to the visiting botanist, who will probably endeavour to explore the Darling Range, and perhaps the Stirling Range, if he makes an extended stay. Here it may be at once said that Western Australia is the State which will probably have most fascination for him, for its pre-eminence as a botanist's paradise is without question. The work of most of the visitors will, however, on this occasion, be entirely devoted to that truncated portion between the mouth of the Murchison on the west and Esperance on the south coast, while the true south-west, a more truncated area still, covers more ground than most can even skim over. In giving the palm to this area, it may be mentioned that a journey in the express to Kalgoorlie will rapidly give some impression of the beauty and variety of the desert flora, while the alpine floras of Tasmania, Victoria, and New South Wales, and the rich brush vegetation of eastern New South Wales and Queensland, come only second in botanical interest to the more obvious botanical glories of the western State.

The yellow-flowered genus *Hibbertia* (DILLENIACEÆ) is widely diffused, and contains about 105 species, more than half of which are peculiar to Western Australia.

The floriferous and beautiful pink-flowering genus *Tetratheca*, of the purely Australian family TREMANDRACEÆ, is almost entirely confined to Western Australia, the exceptions being the protean and widely diffused *T. ericifolia*, Sm. (forms of which have been described under no less than seven names), and two others.

The beautiful genus of shrubs *Thomasia* (STERCULIACEÆ), with 23 species, is confined to Western Australia, with the exception of *T. petalocalyx*, which extends as far east as Victoria.

The Western Australian Pitcher-plant, *Cephalotus follicularis*, Labill. (CEPHALOTACEÆ), in which the radical leaves are converted into pitchers, is peculiar to that State, and is found around Albany, in rich peaty bogs of considerable depth, with the pitchers close to the ground, sheltering under the shadow of long tussocks, say, 3 ft. 6 in. high, of rushes, sedges, Leguminosæ, yellow Sundews, &c. It can hardly be seen except by pulling the tussocks aside.

The *Droseras* (DROSERACEÆ), which are covered with glandular hairs which entangle insects, are found in all the States, but Western Australia is especially rich in them, where they form an important and interesting, if frequently a humble, constituent of the vegetation, for in that State are to be found about 45 out of about 62 Australian species, most of which are very rich in individuals.

The CANDOLLEACEÆ are practically taken up with the genus *Candollea* (*Stylidium*), which, with some difference of opinion as to the limits of a species, has 107 species almost exclusively Australian. It has mostly rosettes of radical leaves, and is remarkable for the elasticity of the column which is formed by the filaments, which are connate with the style. This column is bent back normally, but when touched it suddenly straightens, and hence these plants are known as Trigger Plants. No less than 84 are Western Australian, and the genus is sparingly distributed over the rest of the continent, Queensland and northern Australia being best represented after the western State.

Coming to the LORANTHACEÆ, *Nuytsia floribunda*, R. Br., the gorgeous Tree Mistletoe or Cabbage Tree, is a distinctly wonderful plant. It is a medium-sized tree. which grows on sandy land from King George's Sound to the Murchison, in Western Australia, and the whole of the tree, when in bloom, is one mass of beautiful orange-coloured flowers. It is one of the most gorgeous trees in the world. It is root-parasitic, and hence the very great difficulty of successfully transplanting it. Seedlings are raised without difficulty, but they usually do not attain maturity. The same remarks apply to that allied shrub with sweet-scented flowers, *Atkinsonia ligustrina*, F. v. M., which is sparingly found in the Blue Mountains of New South Wales. The other Mistletoes are chiefly represented by the genus *Loranthus*, which, though not endemic, is so abundant and so conspicuous that visitors cannot fail to observe it. Huge pendant masses will be observed attached to the Eucalypts, whose leaves it somewhat resembles; other species likewise simulate the leaves of various other trees and shrubs to which they are attached. *Nothothixos* is parasitic on *Loranthus*, which contains 26 Australian species.

The HÆMODORACEÆ are almost exclusively Western Australian, the genus *Hæmodorum* alone being found out of that State. Of 17 species, 7 belong to Western Australia, 1 is peculiar to Tasmania, 4 to Northern Australia, 2 to New South Wales, and 1 to Queensland, while 2 are found in both New South Wales and Queensland. The genus *Conostylis* has 38 species; the flowers are dull yellow, and the individuals very numerous. The greatest interest, however, will be given to the so-called "Kangaroo Paws" (*Anigozanthus*), some of which have very brilliant and bizarre colouring. Eleven species have been described.

The IRIDACEÆ are in Australia practically synonymous with *Patersonia* (17 species), largely developed in the western State (12 species), while 4 are in Victoria, 3 in New South Wales, and South Australia, Tasmania, and Queensland having 2 each. The conspicuous but delicate perianth is usually bluish or purplish in colour.

The RESTIONACEÆ are closely allied in habit and inflorescence to the Cyperaceæ, and are noteworthy from the great dissimilarity in habit and inflorescence between the males and females of some species. The family is almost limited to Australia, South Africa, and New Zealand, but our species (rather more than 100) are all endemic. The genera *Restio*, *Leptocarpus*, and *Hypolæna* are also South African, and Australia has 25, 12, and 7 species respectively. These genera, together with *Lepyrodia* (15 species) are diffused throughout Australia, though they have a strong Western Australian

element. *Loxocarya* (9), *Lepidobolus* (4), and some smaller genera are Western Australian.

To here give more than a sketchy account of the flora of Western Australia is out of the question. It is remarkable for its showy and abundant Leguminosæ, for its abundance of endemic beautiful and remarkable Proteaceæ, including the genus *Dryandra* (allied to *Banksia*), for the profusion of its Goodeniaceæ, including the blue *Leschenaultias*, and so on. Its Eucalyptus flora is most interesting. It is, however, not a land of ferns, the number of species found there being under twenty.

(b) South Australia (including part of the Northern Territory).

South Australia and the Northern Territory form a slice taken through the middle of Australia from the Indian Ocean to the Southern Ocean, the western boundary being 129° E. longitude. They are separated from each other by the 26° of S. latitude, while on the east the South Australian boundary is 141° E. longitude, and that of the Northern Territory is 138°.

South Australia is for the greater part of its area, with the important exception of the south-east, comparatively treeless. The sub-tropical portion is for the most part of low elevation, and much of it is sparse open forest and steppes. It is a country of comparatively low rainfall, and the indigenous species are admirably dealt with in Tate's *Flora*, and the introduced plants in J. M. Black's *Naturalized Flora*

Australian Steppes (*Lake Eyre Basin*).—Baldwin Spencer writes.* "There is a vast tract of country comprising the great Lake Eyre Basin, stretching from this eastwards and northwards, into the interior of New South Wales and Queensland, and up to and beyond the Macdonnell Ranges, across which run such intermittent streams as the Cooper, the Warburton the Macumba, the Finke, and the Todd, dry for the greater part of the year, but every now and then at varying intervals of time swollen with heavy floods, which spread out over wide tracts, and for a time transform the whole country into a land covered with a luxuriant growth of vegetation. To this part of the continent the name of the 'Australian Steppes' may be suitably applied."

Favenc speaks of the mystery of the Lake Eyre system of drainage, which lies in the final exit of its waters. The lake is a sink for the rivers flowing into it, and is mostly a dry bed, the southern portion alone holding water. In spite of its army of affluents, it is never full nor visibly affected as a whole, and it has no outlet to the ocean. It is estimated that its watershed is over 400,000 square miles.

Spencer divides the Steppes into Lower Steppes, Higher Steppes, and Desert Country.

Lower Steppes.—From Oodnadatta to Charlotte Waters (here the Northern Territory begins) and the Finke River to the James Range.

These include the Cretaceous table-topped hills and tablelands; these elevated plains slope gradually towards Lake Eyre from an altitude of 1,000 feet above sea-level to 39 feet below sea-level at Lake Eyre. The great Cretaceous formation with its alternating stony or gibber plains, loamy flats, and low-lying terraced hills, is capped with desert sandstone.

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* *Horn Exped. Rep.* i

On the loamy flats, and even gibber plains, the most noticeable plant is *Salsola Kali* L., commonly known as the Roly Poly, detaching itself from the ground, and forming spherical masses perhaps a yard or more in diameter, It is a constant feature of the Cretaceous area. The lines of the water-courses are marked with belts of gum trees and Acacias, chiefly *Eucalyptus rostrata*. Schlect, the River Gum; *E. microtheca*, F. v. M., the Swamp Gum or Box; *Acacia aneura*, F. v. M., the Mulga; *A. cyperophylla*, the Red Mulga; and *A. Cambagei*, R. T. Baker, the Gidgee.

The Higher Steppes comprise the southern part of the James Range and the George Gill and Levi Ranges.

These include—

(*a*) The great central group of the Macdonnell Ranges, trending in a nearly east and west direction for a distance of about 400 miles, and with a width varying from 20 to 50 miles, thus covering an area of more than 10,000 square miles. Several peaks are over 4,000 feet high, while the surrounding country is over 2,000 feet.

(*b*) The James, Waterhouse, George Gill, and Levi Ranges. These have a mean combined width, if we include the intervening plains and valleys, of from 60 to 70 miles. The area occupied by them, therefore, must be more than 15,000 square miles. The highest points are situated in the most northern ridge, as in the case of Mt. Gillen, which is nearly 3,000 feet above sea-level. There is a gradual decrease in elevation in the ranges from north to south, each range to the south constituting as it were a step in the descent from the Macdonnell Ranges to the plains.

On the Higher Steppes are an interesting Cycad and only one (*Macrozamia* (*Encephalartos*) *MacDonnelli*, F. v. M.), one Palm (*Livistona Mariæ*, F. v. M., known in one colony of a hundred individuals only), a Grass Tree (*Xanthorrhœa Thorntoni*, Tate), one Epacrid (*Leucopogon Mitchelli*, Benth.), while there are representatives of the genera *Capparis*, *Hibbertia*, *Melaleuca*, *Grevillea*, *Loranthus*, *Cassia*, *Eremophila*, and trees up to 40 or 50 feet in height of *Acacia salicina*, Lindl.; *Eucalyptus oleosa*, F. v. M., in the form of a Mallee, and a Bloodwood (*E. terminalis*, F. v. M.) are also found.

Speaking of the saxatile vegetation, Professor Tate, in his report on the botany of the Horn Expedition, says that the number of actual species on the tablelands and high level tracts is absolutely few, but that it was in the gorges of the tablelands and on the basal part of the craggy escarpments and their taluses that a varied flora occurs.

What he terms the Larapintine Flora, the flora of the Finke River and the other districts the Horn Expedition traversed, he classifies as follows:—

(1) Exotic species, chiefly oriental.
(2) Endemic species of exotic genera.
(3) Endemic species of Australian genera.

Under (1) he uses the term "exotic" in its derivative sense, for most of the species are ordinarily classed as Australian natives.

Of the "Australasian" genera, he records the following, with five or more species :—

> *Ptilotus* (11), *Swainsona* (7), *Cassia* (10), phyllodineous *Acacias* (24), *Eucalyptus* (10), *Loranthus* (5), *Grevillea* (9), *Calotis* (10), *Helipterum* (10), *Goodenia* (15), *Dicrastylis* (5), *Eremophila* (17).

The Desert Country.—From the George Gill Range to Ayers' Rock and Mt. Olga. This is one of the areas which may be fitly termed desert.

Ayers' Rock and Mt. Olga.—In addition to the mountain ranges referred to under "Higher Steppes," there are some isolated mountains. Rising like an enormous waterworn boulder is that remarkable isolated monolith known as Ayers' Rock. It is situated 32 miles S.S.W. of Lake Amadeus. The rock is quite bare, with the exception that a few fig-trees (*Ficus platypoda*, A. Cunn.) maintain a precarious footing in the few crevices on its bare sides. Mount Olga, which from a distance presents a most remarkable outline, is 15 miles west of Ayers' Rock.

Professor Tate divided intra-tropical South Australia into the *Eremian* or Desert Flora which occupies the arid region of central Australia, and corresponds with the "salt-bush country" of the pastoralist. This is continuous with much country in eastern Western Australia, and western Queensland and New South Wales. The region is approximately limited by the rainfall line of 10 inches.

His second division was the *Euronotian* Flora, which is dominant in the more humid parts of temperate Australia, excepting the extreme south-west.

To speak of the whole interior of Australia as a Desert or Eremian Country is very misleading. Over wide areas, especially across the western half of the interior, extend sand-hills and flats covered with Mulga scrub (*Acacia aneura*, F. v. M.) and Porcupine Grass (*Triodia*), which may be justly described as desert, *e.g.*, some country stretching from the George Gill Range to Ayers' Rock and Mt. Olga, where no creeks run and uncertain water supplies may be found in rock-holes, but the Australian Steppes country of the interior is by no means desert.

Kangaroo Island is the second Australian island in point of size; it is of an oblong shape about 90 miles by 25, and is situated just off the coast of South Australia. The country is hilly and undulating, the highest elevation being under 1,000 feet. There is but little permanent water on the island, and its vegetation is grouped by Tate as heathy, sylvan, and savannah. The flora is not rich, consisting of less than 400 species of phanerogams and vascular cryptogams. Very few species are endemic. Its flora bears strong affinity to that of the mainland, and is remarkable for the strong Tasmanian element it contains.

South Australia, taken as a whole, is not remarkable for the number of its endemic plants: most of them are in common with the indefinitely-zoned dry areas of the contiguous States.

(c) Victoria.

Victoria is a State which in its eastern portion (Gippsland) has conditions which strongly resemble those of the southern coastal belt of New South Wales. It is the home of the tallest trees of the Australian continent.

probably second only in this respect to those of California. In the south-west we have a basaltic plain which is remarkably fertile. This has scattered forests, and is pastoral and agricultural country. North of these areas are the western and eastern highlands, the latter higher and moister, and both containing rich open forests consisting almost entirely of Eucalyptus. In the Wimmera, in the north-western portion, we have a region of comparatively low rainfall, similar to much of the South Australian territory adjacent and to the western plains of New South Wales.

No State of the Commonwealth has had its flora more fully examined than Victoria, since the late Baron von Mueller was for so many years Government Botanist of that State; indeed he took unofficial botanical charge of the whole of Australia. For purposes of botanical-geography he divided the State into five parts, chiefly based on the river systems:—

(*a*) The north-western region, from the sources of the water-courses in the north-west to the Murray River. This is the driest area.

(*b*) The south-west region, from the sources of the water-courses in the south-west, to the coast west of Cape Otway and to the vicinity of the Glenelg River. This includes much rich plains country.

(*c*) The southern region, from the sources of the water-courses in the south to the vicinity of Cape Otway to Port Phillip (Melbourne district), and to the western boundary of Gippsland.

(*d*) The north-eastern region, from the sources of the water-courses in the north-east to the Hume River, including the Victorian Alps. Here we have the alpine vegetation contiguous to that of New South Wales, and with a strong Tasmanian and Antarctic element.

(*e*) The eastern region, comprising Gippsland, exclusive of the Alps. This is an especially well-watered area, and a celebrated forest region, including the habitat of the tallest trees of Australia.

The Otway district is a well-known forest region, *e.g.*, for its magnificent Blue Gum (*Eucalyptus globulus*, Labill.) areas, and for the Beech forests (*Fagus Cunninghamii*, Hook. f.).

Admirable general accounts of the flora of Victoria have been given by C. A. Topp,* G. Weindorfer,† and Professor A. J. Ewart.‡

Topp characterizes the prevailing botanical features, first of the shores of Port Phillip and of the district in its immediate vicinity, then the flora of the fern-tree gullies (in which Victoria is rich), such as may be found in the Dandenong Range and on the Main Divide, running into the Watts' River and other mountain streams, and, thirdly, he gives a brief account of the interesting alpine flora of the north-eastern mountain system, between Omeo and Harrietville, on the peaks and spurs of Mts. Feathertop, Bogong, and Hotham.

Weindorfer divides the State into three, the first and largest of which forms part of the south-eastern Australian forest flora, and is looked upon as an intermediate link between the Antarctic flora and that of the tropical east and north of the continent. The second division is formed by a part of the central Australian desert flora, which penetrates to the north-west corner

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* *Handbook Aust. Assoc. Adv. Sci., Melbourne*, 1900, p. 170.
† *Victorian Year-Book* 1904, Part i., p. 19.
‡ *Vict. Nat.* xxv., 78 (1908).

of the State, constituting the "Mallee" (Mueller's north-west region). The third and smallest division is the alpine flora, which is restricted to the highest points of the alpine mountains in the north-eastern corner of the State (Mueller's north-eastern region). Weindorfer's first large division therefore includes the divisions (*b*), (*c*), (*e*) of Mueller.

He points out that Victoria's endemic flora is 7·6 per cent. (46 species in all) less than that of the floras of any of the other States, and is to be accounted for by the comparatively regular and heavy rainfall over a large area, and which caused Sir Thomas Mitchell, Surveyor-General of New South Wales, to designate the central portion of it "Australia Felix."

The Grampians form what have been termed the natural garden of Victoria, for the flora of this range is alike varied and beautiful.

Ewart's paper is more ecological in character, being written less from the taxonomic side. He deals with the factors which influence a flora, and briefly applies them to Victoria in the form of notes. Thus he touches upon geological history, present climate, the effect of settlement on the native flora, and cognate subjects in pregnant paragraphs.

Under *Eucalyptus regnans*, F. v. M., which the author has recommended to be known as "Giant Gum," there is given* a full account of the Giant Trees of Australia, together with a record of the controversies which took place nearly 30 years ago. The tallest trees in Australia, so far proved, are those of Gippsland, Victoria, and are *E. regnans*, F. v. M. Claimants for this distinction are the giant Karris (*E. diversicolor*, F. v. M.), of south-western Australia, but the heights assigned to this species require confirmation by surveyors. The "King-trees" of eastern New South Wales, viz., the Blackbutts (*E. pilularis*, Sm.), of the Illawarra, and the Tallow-woods (*E. microcorys*, F. v. M.) of the Lansdowne River, may be as bulky (though not so high) as the Gippsland trees, but this requires to be proved.

The official size of the tallest Gippsland tree is given as—height, 326 ft. 1 in.; girth, 25 ft. 7 in., measured 6 feet from ground; locality, spur of Mt. Baw Baw, 91 miles from Melbourne. This is enormous, but different from the alleged heights of from 400 to 525 feet foisted on Mueller, and which will probably not be eradicated from the newspapers for another generation.

As regards the Californian trees brought into comparison, Prof. Sargent, an eminent authority, may be quoted, and in view of the actual measurements that he presents, viz., 340 feet in height for a Redwood and a girth round the trunk of 107 feet for its congener the "Big Tree," an opinion may be expressed that, so far as is known at present, California is the home both of the tallest and of the broadest trees in the world. The difference (under 14 feet) against the Gippsland tree is not large, and it would not be surprising if additional investigations should cause this friendly competition between Australia and the United States to end differently.

(d) Tasmania.

This is by far the smallest of the Australian States, but by reason of its generous rainfall, comparatively high latitude, and great range of elevation, it is a paradise of "antarctic" plants for the botanist.

* "Forest Flora of New South Wales," Part XVIII., p. 161.

It has a climate which greatly resembles that of Britain. It is well wooded, not only with Eucalypts, but with Beeches (*Fagus Cunninghamii*, Hook. f.), and with valuable Conifers, Huon Pine (*Dacrydium Franklinii*, Hook. f.), King William Pine (*Arthrotaxis selaginoides*, Don, and *cupressoides*, Don), Celery Top Pine (*Phyllocladus rhomboidalis*, Rich.), Oyster Bay Pine (*Callitris rhomboidea*, R. Br.), now seriously diminishing. The western portion is a region of high rainfall, and the Beech forests are almost impenetrable.

A singular plant is the endemic *Anodopetalum biglandulosum*, A. Cunn. (Saxifrageæ), a tree common in the forests of the south and west, and which grows in a remarkable horizontal position, hence the name "Horizontal Scrub."

The flora of Tasmania and its relations are very well known, originally through the classical work of Hooker,* and, later, through an admirable "Flora,"† the work of the present Government Botanist.

Hooker refers to the strong east Australian character of the flora, the island having been formerly joined to the mainland, and of the non-Australian element he points out the greater proportion of New Zealand, South American, Antarctic, and even European plants not found on the Australian continent.

The strong affinity of the Tasmanian and Australian alpine flora is obvious to any student who examines the two lists, and in most cases the isolation of the two areas has not been continued for a sufficiently long period to bring about any obvious difference in the facies of the plants. The Tasmanian affinities in the Australian floras can be traced, in diminishing abundance, over distant regions of the mainland.

In view of the distribution of the true Beeches (*Fagus*), it may be noted that there are three species, *F. Gunnii*, Hook. f. (Fagaceæ), a small shrub confined to a few mountain summits in Tasmania, *F. Cunninghamii*, Hook. f., the so-called Myrtle, a large and beautiful tree found in Tasmania and Victoria, and *F. Moorei*, F. v. M., "Negro-head Beech," also a beautiful tree, occurring on some of the coastal tablelands of central New South Wales, far removed geographically from its congeners.

Reference may be made to a suggestive paper by Rodway‡ in which he discusses the origin of the flora of his State, *e.g.*, the Tasmanian and Fuegian *Fagi*, and notes the presence of almost identical parasitic *Cyttarias* in both countries.

(e) New South Wales.

New South Wales is a State whose botanical conditions are largely comparable to those of Queensland. The climatic factors vary from temperate to sub-tropical.

She has the rich coastal belt, then the elevated tablelands which fall away to the western plains, which are only barren when no rain falls. Her coastal belt, and gullies running into the ranges and tablelands, produce many "brush" timbers, at the same time supporting various types of open forest, while the western slopes and plains produce valuable small trees acclimatised to regions of low rainfall.

* *Flora Tasmaniæ.*
† *The Tasmanian Flora* by Leonard Rodway (1903)
‡ *Proc. A.A.A.S.*, xiii 250

New South Wales joins with Queensland in her brush vegetation; with Victoria and Tasmania as regards alpine plants; in her western slopes and wide western plains with Western Australia, and the rest of the continent in a share of the true Australian indigenous flora.

Many distinctive New South Wales plants will, therefore, be found referred to under Queensland; a very brief statement may be made in regard to the endemic flora of the parent State. Endemism must be usually spoken of with a qualification, for every year are found important additions to the reputed restricted habitats of plants.

They include two species of *Streptothamus* (Flacourtiaceæ), both climbing plants from the northern rivers, a few bipinnate *Acacias*, and a few Eucalypts.

In the Saxifrageæ is the important genus *Ceratopetalum*, comprising two handsome coastal trees, the flowers of "Christmas-tree or Bush" (*C. gummiferum*, Sm.) being especially beautiful; also *Acrophyllum venosum*, Benth., a charming shrub of the Blue Mountains.

Amongst the Proteaceæ are the small genus *Symphyonema*, the only *Lambertia* out of Western Australia, and a number of *Grevilleas*, the handsomest of the *Telopeas* (*T. speciosissima*, R. Br., the Waratah); a few Goodeniaceæ and Compositæ, some *Prostantheras*, a few *Styphelias*, *Leucopogons*, and *Epacris*; some of the smaller species of *Macrozamia*, amongst orchids, one or two each of *Dendrobium*, *Sarcochilus*, *Diuris*, *Prasophyllum*, and *Pterostylis*.

Further, a *Hæmodorum* (Hæmadoraceæ). In the Liliaceæ, a couple of *Blandfordias*, an *Allania*, a *Xerotis*, and a *Xanthorrhœa*. Amongst the Restionaceæ, a *Lepyrodia* and a *Restio*; and in the Cyperaceæ, a very few species of *Cyperus*, *Scirpus*, *Schœnus*, and *Gahnia*; also a very few grasses.

There are two regions of abundant and large arboreal vegetation, namely, south-western and eastern Australia. Allusion has already been made to Gippsland, and there is also the coastal strip running along New South Wales and Queensland to Cape York. In both the latter States the Great Divide plays an important part in consideration of the distribution of the vegetation, but it is a common error to confuse it with the coastal ranges, or, indeed, to call it a range at all. It is, as Favenc has pointed out, the true edge of the interior plateau.

In the south coast district are arborescent Rubiaceæ (*Coprosma* and *Canthium*), arborescent Compositæ (*Aster argophyllus*, Labill., *Bedfordia salicina*, DC., etc.).

In the north coast, also a branch of the coastal strip, are found arborescent baccate Myrtaceæ (*Eugenia*, &c.), arborescent Proteaceæ, *Brachychitons*, *Laporteas*, &c., with *Diploglottis Cunninghami*, Hook. f., *Panax elegans*, F. v. M., and *Archontophœnix Cunninghami* (Bangalow), lifting their graceful heads amongst the surrounding vegetation.

The coastal strip has or had trees which, although not the highest, may be the bulkiest of all Australian trees, *Eucalyptus pilularis*, Sm., and *E. microcorys*, F. v. M., already referred to.

The Cypress Pine forests of the western plains, and the Ironbark forests from Dubbo and north-eastward, are examples of pure gregarious forest.

(f) Queensland.

Queensland is a region of rich coastal vine brushes (scrubs), tropical and sub-tropical, with rich basaltic or at least alluvial soils, and ample rainfall. It contains a marvellous variety of trees, some of them very large, and some of ascertained economic value. Westerly there are broken elevated tablelands with rolling country beyond, much of it covered with open forest, of which *Eucalyptus* is an important constituent, and then, sloping away to the centre of Australia, are found conditions rarely favorable to tree life.

The best general account of the vegetation of Queensland is by Domin.*

It is in this State that the Austro-Malayan element is most developed, and it is very important, particularly in the Cape York Peninsula. The Antarctic element is of very much less importance, and chiefly in evidence on the tops of the Bellenden-Ker Range, the highest land in the State. The true endemic flora is seen chiefly in the rolling downs and western plains, also in southern Queensland.

The botano-geographical conditions are much the same as those already indicated for New South Wales, an outstanding feature being the greater extent of the rich soil of the coastal districts, together with a higher rainfall and of course a warmer climate, for the territory extends into the tropics. The result is a rich "brush" vegetation, far exceeding that to be found in any other part of Australia, and systematists will not exhaust the treasures for very many years.

Mr. F. M. Bailey has already described very many species, and the difficulty of botanizing in the brushes is only known to those who have had experience of it. The tall trees grow lofty and near together like cathedral columns, exhibiting their commingled canopies to the sky, and much of the botanical material available is owing to windfalls and the breaking down by animals. Owing to the loftiness and the darkness, one often cannot see either flower or fruit, and if one shoots off a twig, it is often not recovered, and, even if obtained, it frequently cannot be matched with the tree which produced it. The tall creepers which run to the tops of the loftiest trees are even more difficult to examine.

The numerous ranges and isolated mountains of Queensland afford rich collecting grounds to the botanists, who can be certain of harvests of such plants as orchids, palms, and ferns. To some extent Queensland is the antithesis of Western Australia, but her total of recorded plants already exceeds that of Western Australia. These two States, partly because of their size, have been least botanically explored. Queensland's boundless prairies are rich in natural grasses and forage plants, which render her one of the greatest cattle and sheep-raising countries in the world.

Most of the Anonaceæ are confined to Queensland (brushes), though five species come as far south as New South Wales and one (*Eupomatia laurina*, R. Br.) to Victoria.

The Meliaceæ are another family of trees almost entirely restricted to the brushes of coastal New South Wales and Queensland, the exceptions being confined—(*a*) to the genus *Owenia*, the inland "Colane," *O. acidula*, F. v. M., extending to South Australia, while *O. reticulata*, F. v. M., is the only representative of the family in Western Australia, in which State it is

* "Queensland's Plant Associations" *Proc. Roy. Soc.*, Q. xxiii, 57

endemic; (*b*) to *Flindersia maculosa*, the "Leopard Wood" of the drier portions of both States. The genus *Flindersia*, or "Rasp-pod," is so called because of its usually large, muricate, septicidally-opening capsules, and fifteen species have now been described. Engler proposes to place it with the Rutaceæ. There is abundance of *Dysoxylon*, and *Cedrela australis*, F. v. M., is the well-known "Red Cedar."

There are about twenty species of Vitis (Viticeæ), all confined to the brushes of Queensland and New South Wales, with the exception that two extend to Victoria, on the south, and one species (*V. angustissima*, F. v. M.) is peculiar to Western Australia. Some form lianes of great size, and are water yielders; some have been tried as Phylloxera-resistant stocks, but with no commercial success so far.

Very extraordinary are the bladder-like organs of *Utricularia* (Lentibularineæ), dainty little plants found in damp sandy land, which are modified leaflets. They have a valve-like arrangement, which enables them to catch minute water animals. There are 24 species, seven of them extending to Asia. Most have been described from Queensland, but they are not rare in New South Wales and Western Australia.

Pitcher-plants, Nepenthes (Nepenthaceæ), in which the blade expands into a pitcher or ascidium, and the prolongation of the midrib into a lid-like process, are practically confined (in Australia) to the Cape York Peninsula. Mr. F. M. Bailey has described no less than ten new species from this district, all believed to be endemic. Only one non-endemic species (*N. phyllamphora*, Willd.) is recorded from Australia and the Pacific Islands.

Amongst parasitic plants the leafless *Cassytha* of the Laur ceæ, which covers shrubs with a tangled mass of twine, will be certainly seen by the visitor. There are also some native Dodders (*Cuscuta*), but an imported species (*C. Epithymum*, Murr.) is a serious pest, particularly to lucerne, and is, as a general rule, treated with severity. With the exception of *Cassytha*, which occurs more or less all over the States, the Lauraceæ are tall trees of the coastal brushes, confined to New South Wales and Queensland, particularly the latter, four species extending to Asia. Sixteen species of *Cryptocarya* and fifteen of *Endiandra* have been described.

Many of the species of Euphorbiaceæ are widely diffused, but some genera, particularly those of Tribe Crotoneæ, are predominantly eastern, being found in Queensland or extending to New South Wales. The family includes some doubtful poison plants.

The genus *Ficus* (Moraceæ) is almost entirely confined to the brushes of eastern Australia, largely preponderating in Queensland, with many species extending northerly into the Northern Territory, two (*F. platypoda*, A. Cunn., and *orbicularis*, A. Cunn.) finding their way into the centre of the continent. Southward a number of species are found in New South Wales. Some of the species are hemi-epiphytes, completely obliterating even large trees and fences unless controlled. The whole family has the same general distribution in Australia, being fond of moisture, deep soil, and warmth. There are three species of *Laportea* (Nettle Tree)

Turning to the Orchidaceæ, of which Australia has 139 species, there are not many Australian orchids which especially attract the orchid grower. *Dendrobium bigibbum*, Lindl., *D. superbiens*, Reichb., *D. phalænopsis*, Fitzg

(resembling *superbiens*), and *D. undulatum* var. *Broomfieldi* (a handsome north Australian variety with yellow flowers), *D. speciosum*, Sm., the "Rock Lily," with lemon yellow flowers, and *D. falcorostrum*, Fitzg., are certainly meritorious. *Sarcochilus Fitzgeraldi*, F. v. M., is the most beautiful of the genus, and worthy of cultivation.

Caladenia Patersoni, R. Br., is reckoned by some to be the most charming of Australian terrestrial orchids. The Epiphytes are most developed in the brush forests of New South Wales and Queensland; the terrestrial ones are diffused throughout the States.

Calanthe veratrifolia, R. Br., with white flowers, *Phaius grandifolius*, Lour., var. *Bernaysi*, with yellow flowers, and *Spathoglottis Paulineæ*, with reddish-brown ones, are handsome large terrestrials. Interesting leafless orchids are *Galeola cassythioides*, A. Cunn., not rare about Sydney; *G. Ledgeri*, F. v. M., a very handsome denizen of the brush forests; and *Gastrodia sesamoides*, Lindl.

The approximate number of the Australian species is given as follows:—*Caladenia*, 56; *Prasophyllum*, 47; *Dendrobium*, 45; *Pterostylis* (Greenhoods), 40; *Thelymitra*, 30 (*T. grandiflora*, Fitzg., with blue flowers is very handsome); *Diuris*, 25; *Sarcochilus*, 24. Orchids are pre-eminently a family to be studied in the fresh state, with a flora available for reference, and justice cannot be done to these beautiful and interesting plants in the brief space available on the present occasion.

PALMÆ.—The Palms of Australia are confined to the brush forests of Eastern Australia, and are mainly found in Queensland. New South Wales has *Calamus Muelleri*, Wendl. (a "Lawyer Palm"), *Linospadix monostachyus*, Wendl. and Drude (Walking Stick Palm), *Archontophœnix Cunninghamiana*, Wendl. and Drude (Bangalow), and *Livistona australis*, Mart. (Cabbage Palm), the last extending into eastern Victoria, while *L. Mariæ*, F. v. M., the only palm of the interior, is found in the Macdonnell Ranges of South Australia.

Queensland has six species of *Calamus*, six of *Livistona*, two of *Bacularia*, two of *Gulubia*, one each of *Calyptrocalyx*, *Drymophlaeus*, *Areca*, *Cocos* (the Coco-nut), *Caryota*, *Licuala*, *Corypha*, and *Borassus*. The student of palms will be charmed with Queensland, and he will also find several *Pandani* and *Freycinetias* in the same State, only one *Pandanus* (*pedunculatus*, R. Br.) extending south down the New South Wales coast.

CHAPTER VI.

THE ANIMAL LIFE OF AUSTRALIA.

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SYNOPSIS.

1. Introduction.

In view of the narrow limits necessarily imposed, I have considered it best not only to restrict the following statements to the animals of the land and fresh water, leaving the marine fauna untouched, but also to leave out of account a number of terrestrial and aquatic groups, which, however important and interesting, are not known to contribute any characteristic features to the Australian fauna. Thus the Protozoa, the Parasitic Worms, the Rotifers, certain orders of Insects and Arachnida, and certain orders of Birds, though quite as extensively developed in this region as in others, are not referred to in the following survey.

The features distinguishing the fauna of Australia from that of the other main divisions of the earth's surface are by no means confined to the larger and more conspicuous animals. Many of the lower groups, in spite of the presence throughout most of them of cosmopolitan or widely-distributed forms, have their characteristic Australian facies.

2. The Mammals.

It is the **Mammals,** however, that constitute, on the whole, the most interesting part of the Australian fauna—interesting not only on account of their peculiarities of structure and mode of life, but also on account of the fact that in their case more than in that of any of the other groups, it is possible through fossil remains to trace their history in past geological periods, and from this, together with their present distribution, to draw deductions of importance regarding changes in the arrangement of the land-surfaces of the globe in the less remote geological periods.

The entire Australian mammalian fauna, with the exception of the Dingo or Native Dog, a few Rodents, a number of Bats, including Fruit-eating Bats or Flying Foxes, and in the sea the Seals and Whales and Dugongs, is composed of Marsupials and Monotremes.

(a) The Monotremes.

The most primitive of all the orders of Mammals—the *Monotremes*—are entirely confined to Australia, including Tasmania, and New Guinea. Not only is this the case, but there is no evidence of any members of this primitive group having existed in other parts of the world later than, at the latest, the oldest division (Lower Eocene) of the Tertiary period. It is possible, as held by some, that all the Mammals, remains of which, chiefly in the shape of lower jaws with teeth, have been found in Mesozoic strata in Europe, were near allies of the existing Australian Monotremes. But, be this as it may, there is good evidence from the resemblance in their tooth-structure to the living *Ornithorhynchus* that the small European Mesozoic Mammals known as the *Multituberculata* were the ancestors of the Australian Monotremes. It is somewhat remarkable that no remains capable of being referred to the Monotremes or their supposed ancestors have up to the present been found in any part of the world but Europe and North America on the one hand, and Australia on the other.

Little is known with regard to the structure of the long-extinct Multituberculates, but what is known does not point to any high degree of specialization, except in so far as the teeth are concerned. The living Monotremes—the Platypus or Duck-bill (*Ornithorhynchus*) and the Spiny Ant-eater (*Echidna*)—on the other hand, are extremely specialized, and must differ very widely from their supposed ancestors. Both are very remarkable creatures, and remarkable in very different ways, for, though their relationship in essentials—in the structure of their shoulder-girdle, for example, and in their oviparity with all that goes with it—is indisputable, their divergence in more superficial points is extreme. The resemblances are confined superficially to the general shape of the trunk, to the presence of short thick limbs, all provided (except in the Papuan *Pro-Echidna*) with the full complement of five digits, which are sub-equal and have strong claws, with a horny spur on the inner side of the hind foot, in addition to the elongation of the snout region into a kind of beak. In other respects the differences are very marked.

The Platypus is covered with a fine close fur. The upper jaw is not unlike the beak of a Duck in general appearance, and is covered with a hairless, leathery-looking integument, which is developed into a free flap at the base in front of the eyes. Both fore and hind limbs are short, and each comprises five digits connected by a web of skin, but provided with strong claws, so that they are adapted both for swimming and for burrowing. In the male there is a sharp horny spur, provided with a gland, on the inner side of the foot. The tail is long and furry.

The Spiny Ant-eater (*Echidna*), on the other hand, has the upper surface of the body covered with strong pointed spines like those of a Hedgehog, but larger, with coarse hairs in between. The snout is very narrow and the tail is rudimentary. The digits, which are specially powerful in the fore feet, are not connected by webs.

Echidna and *Ornithorhynchus* are both animals the study of which in their native haunts is difficult. Their habits are nocturnal, and they remain for the most part securely concealed during the day. The food of *Echidna* under natural conditions consists of ants, for the capture of which its long and narrow tongue is specially adapted. It possesses no trace of teeth at any

stage. During the day it is rarely seen in the open, hiding away in holes among rocks or about the roots of trees. If alarmed during its rare wanderings abroad in the day-time it rapidly buries itself by burrowing downwards.

The Platypus spends most of its active life in fresh-water pools and streams, swimming and diving with dexterity, and seeking its food, in the shape of molluscs, insect-larvæ, and the like, among the water-weeds, using its beak as a Duck uses its bill for seeking out such objects, which are then stored in cheek-pouches, to be afterwards crushed between the broad horny plates that do duty for teeth in the adult. The Platypus, like *Echidna*, is hard to find even in districts where it is abundant, since it retires during the day to a burrow excavated in the banks of the stream, and, when in the water, shows very little above the surface.

Though the adult Platypus has no teeth, well-developed teeth are formed in the young, and persist for a considerable time. The peculiar structure of these teeth has led to the conclusion, already referred to, that the nearest known relatives of the Monotremes are the extinct Mesozoic and Lower Eocene *Multituberculata*.

Ornithorhynchus and *Echidna* are oviparous. *Echidna* produces usually only one egg in a season; this it carries about and incubates in a temporarily-formed pouch into which the ducts of the mammary glands open, and, after the young *Echidna* is hatched, it is carried about in the pouch for a considerable time.

The Platypus has no pouch, and the two eggs usually produced are deposited in the interior of the burrow, where the young are hatched.

Both Platypus and *Echidna* are still fairly abundant in some parts of the Commonwealth, though the numbers of the former have been reduced owing to the demand for their pelts, which are highly valued. Both are, nominally at least, protected by legislative enactment. Neither can be said to be in any immediate danger of extinction; and, owing to the disappearance of the aboriginals, formerly their chief enemies, in most districts, the *Echidnas* are probably rather increasing than diminishing in numbers in some parts. *Echidna* ranges over all parts of the Continent, Tasmania, and parts of New Guinea.

(b) The Marsupials.

The Australian region is peculiarly the home of the *Marsupials* at the present day, and in it, as has been frequently pointed out, owing to their having remained for a long period practically undisturbed by aggression or competition at the hands of the higher orders, they have been able to adapt themselves to a great variety of widely differing modes of life. These adaptations have resulted in the evolution of a number of families which show a distinct parallelism to certain of the groups of the *Eutheria* or higher Mammals Thus the Kangaroos and Wallabies, herbivorous Mammals with the limbs adapted for swift locomotion on the ground, are the Marsupial parallels of the Deer and other Ruminants. The arboreal Phalangers and Koalas may be compared to the arboreal Lemurs and Monkeys. The Flying Phalangers are comparable to the Flying Squirrels. The Bandicoots, on the one hand, and the Wombats on the other, mimic some of the families of Rodents. The carnivorous Native Cats, Tasmanian Devil, and Thylacine parallel some

of the groups of the true *Carnivora*, while the Moles among the Insectivora find an analogue among the Marsupials in the *Notoryctes* or Marsupial Mole of the Australian desert.

When we take this high degree of specialization into account, it is difficult to believe that the Marsupials are a degenerate race. Yet some of the zoologists who have given most attention to the subject are of the opinion that the existing members of the order have been derived from ancestors more highly organized than themselves in certain important respects. One part of the evidence on which this view is founded is concerned with the dentition. Germs of three sets of teeth are developed in young Marsupials; but of these three sets of germs only one gives rise to a set of fully-formed teeth—the teeth of the adult. If the latter are the persistent *milk-teeth*, as some comparative anatomists suppose, then one of the sets that remain undeveloped may be regarded as corresponding to the *permanent teeth* of higher Mammals; and, should this be correct, then degeneration, as regards the teeth, has certainly taken place in the Marsupials. But the presence of the two abortive sets of tooth-germs does not necessarily point to such a conclusion; it may very well be interpreted as pointing not to *degeneration* from higher Mammals, but to progressive development from lower forms in which three, or more, sets of teeth succeeded one another during the life of the animal.

Another fact that has been looked upon as favouring the theory of degeneration is the singular one that only one Marsupial, so far as known, —the Bandicoot, *Perameles*, as discovered by J. P. Hill—has a true or allantoic *placenta*, such as is universally present, as the organ for the absorption of nutriment by the unborn young, in all higher Mammals without exception. The explanation of this anomaly afforded by a theory of degeneration—viz., that Marsupials in general once possessed a placenta, and that it has become degenerated and lost in all except *Perameles* is, however, not the only one that might be given. Almost as well might one argue that since among the Lizards one form, viz., *Seps*, has an allantoic placenta, all the others have previously possessed this structure, but have lost it as a result of degeneration. It is perhaps quite as probable that the placenta has been independently evolved in the Marsupials and in the ancestors of the higher Mammals.

A third fact that has been supposed to point to degeneration is that the oldest known extinct Australian Marsupial, *Wynyardia*, described by Baldwin Spencer from deposits of Eocene age in Tasmania, has a cranial cavity, and presumably possessed a brain, larger in proportion than those of the living forms.

The Marsupials are divisible into two main sections or sub-orders—the *Diprotodontia* and the *Polyprotodontia*. The *Diprotodontia* have two large incisor teeth in the lower jaw, and usually six (three on each side) in the upper; and they all have the second and third toes (usually much smaller than the others) united by a web of skin (syndactylous); while the *Polyprotodontia*, which are carnivorous or insectivorous for the most part, have numerous incisors (four or five pairs) in the upper jaw, and rather fewer in the lower, and, with the exception of the Bandicoots, are not syndactylous.

If we leave out of account the doubtful case of the South American *Cœnolestes* and allied extinct forms from the Santa Cruz beds of Patagonia, the Diprotodonts are exclusively Australian at the present time, and there

is no evidence that they ever existed in any other region. There are three families of Diprotodonts—the Kangaroo family (*Macropodidæ*), the Wombat family (*Phascolomyidæ*) and the Phalanger family (*Phalangeridæ*). The first includes, in addition to the Kangaroos, the Tree Kangaroos, the Wallabies, the Rock Wallabies, Hare-Wallabies, and Rat-Kangaroos, ranging in length of head and body from 5 ft. 5 in. in the case of the large Kangaroos, down to 10 inches in the case of the Musk Rat (*Hypsiprymnodon moschatus*). There are at least four species of Kangaroos (*i.e.*, of the large species of *Macropus*) inhabiting chiefly the more central parts of the various States, and two of them also occurring in small numbers in the arid Central Australia. The commonest is the Giant Kangaroo (*Macropus gigas*) which does not extend to Central Australia, but is found all over the rest of the Continent, except the far north, a variety of the species, now very rare, occurring also in Tasmania.

The Wombats (*Phascolomyidæ*), thick-set in body, short in legs, practically tailless, and clumsy in movement, contrast strongly with the agile and graceful Kangaroos and Wallabies. Their front teeth are very rodent-like, and they have been not inaptly described as resembling Beavers in general appearance without the well-developed tails of the latter animals. The short and very stout limbs are provided with powerful claws, which enable the animal to excavate large burrows in which it usually lies hidden during the day-time. It employs its burrowing powers also in procuring the roots of ferns and other plants which form the staple of its food. The most widely distributed species is *Phascolomys mitchelli*, which is found in New South Wales, Victoria, and South Australia. A second species (*P. ursinus*) is confined to Tasmania and the islands of Bass Strait, while a third (*P. latifrons*) occurs in South Australia.

The family *Phalangeridæ* includes, in addition to the Phalangers, almost universally known as " Opossums " in Australia, the Koala or Native Bear. Of the latter there is only a single species (*Phascolarctus cinereus*) which is common all over Eastern Australia. It is almost as completely arboreal in its habits as the Sloth, which it resembles also in its slow and deliberate movements. Both hand and foot are prehensile, and the digits are provided with strong curved claws; the tail is vestigial. The food of the Koala is composed almost exclusively of leaves of Eucalypti. During the day it usually rests asleep in a forked branch.

The Phalangers are slighter in the body than the Koala, and have similar prehensile limbs, but are provided with a long tail which is usually prehensile. The commonest species is *Trichosurus vulpecula*, which is found over all Australia with the exception of the Cape York District. The common Tasmanian Opossum is a somewhat larger variety of the same species with darker and thicker fur. A second species—the Short-eared Opossum—*T. caninus*—is not so widely distributed, being found in Southern Queensland, New South Wales, parts of Victoria, Tasmania, and the islands of Bass Straits.

The Ring-tailed Opossums (*Pseudochirus*) are similar to the Opossums, but smaller. The Flying Opossums (" Flying Squirrels ") differ from the Opossums in the possession, like the true Flying Squirrels, of a fold of skin extending on each side of the body from fore limb to hind limb, and forming a parachute enabling the animal to glide through the air from one branch

of a tree to another. Of these the largest is the Greater Flying Opossum (*Petauroides volans*), which occurs throughout Eastern Australia. The smallest is the Pigmy Flying Opossum (*Acrobates pygmæus*), of about the size of a mouse.

Also mouse-like in size and general appearance is the Long-snouted Pouched Mouse (*Tarsipes rostratus*) which is peculiar among the Marsupials in feeding with the aid of its long tongue on the honey of flowers as well as on insects. *Tarsipes* has only been found in Western Australia.

One of the rarest and most interesting of the Australian *Polyprotodonts* is the little Banded Ant-eater (*Myrmecobius fasciatus*) of South and Western Australia. Of the size of a large Rat, the Banded Ant-eater has a slender squirrel-like body, a pointed snout with a long narrow tongue, well-developed claws on the five digits of the fore foot and the four of the hind foot, and a long bushy tail. The coarse, reddish fur of the upper surface is crossed by eight or nine light transverse bands. The teeth are remarkable on account both of their great number—52 altogether, a larger number than in any other living land Mammal—and of the close resemblance between them and the teeth of certain of the oldest known fossil Mammals, the remains of which have been found in European Jurassic beds. Though a Marsupial in all other essential respects, *Myrmecobius* is devoid of the characteristic pouch or marsupium which occurs in all the rest of the Australian members of the order.

Of the family *Dasyuridæ* the Native Cats (genus *Dasyurus*) comprise five species of carnivorous, marten-like, partly terrestrial, partly arboreal Marsupials, the largest of which, the Tiger-cat (*Dasyurus maculatus*) is about 3½ feet in total length. They have all brownish or yellowish-grey fur with white spots. The most widely-distributed of the Native Cats is *Dasyurus viverrinus*, which occurs in New South Wales, Victoria, South Australia, and Tasmania. A number of smaller, rat-like or mouse-like forms are also comprised in the family.

To the same family are also referred the Tasmanian Devil and the Thylacine. The Tasmania Devil (*Sarcophilus ursinus*), now confined to Tasmania, but formerly—probably at a period when Tasmania was a peninsula—living also in continental Australia, is a fierce little animal which in general appearance, with its thick snout and thick-set body, has been compared to a small Bear. The limbs are like those of the Native Cats, but stronger, with five clawed digits in the fore and four in the hind foot. The fur is black, with sundry patches of white.

The Thylacine or Tasmanian Wolf (*Thylacinus cynocephalus*), like *Sarcophilus*, is now confined to Tasmania, though formerly occurring on the mainland. *Thylacinus* is a large dog-like carnivorous Marsupial of a grey colour, with a number of transverse blackish stripes on the hinder part of the body. It is said to find its nearest relatives in certain fossil forms (*Prothylacinus* and others), in the Santa Cruz beds of Patagonia. Both the Devil and the Wolf have been driven back to the very wildest and roughest parts of Tasmania, and are becoming very scarce.

The Bandicoot family (*Peramelidæ*) are Polyprotodonts which resemble the Diprotodonts in having the second and third toes of the hind foot syndactylous, *i.e.*, united together by a web of skin. They are rabbit-like,

burrowing, omnivorous, with two or three of the middle digits of the fore foot long and clawed, the others rudimentary: with the first toe (hallux) of the hind foot absent or rudimentary, the second and third slender and united, the fourth the largest, with a large claw, and the fifth smaller; the tail narrow and sometimes bare like that of a Rat, sometimes scantily haired, sometimes provided with a brush of long hairs.

The common Bandicoots belong to the genus *Perameles*, of which there are six species, the most widely distributed being *P. obesula*, occurring all over Australia south of the Tropics and in Tasmania. Bandicoots are extremely common in some parts of the country, even in the neighbourhood of large towns. They are not frequently seen, as they hide away during the day; but traces of their presence in localities where they abound are usually to be observed in the shape of the numerous shallow burrows which they excavate in search of the roots and the earthworms and grubs which constitute their chief food.

The Rabbit Bandicoot (*Peragale lagotis*) occurs in South and Western Australia and in the Centre. The name is derived from the long ears, which are not unlike those of a rabbit or a hare. Still rarer is the Pig-footed Bandicoot (*Chæropus castanotis*), also with prominent ears and with very slender feet; it is confined to the far-inland parts of the continent.

Of all the Polyprotodonts the most remarkably modified is the little Marsupial Mole (*Notoryctes typhlops*) of Central Australia. The head and trunk together are about 6 inches long, the head passing into the trunk without definite neck: the trunk is flattened, the surface covered with a soft silky fur. The snout is protected above by a hard horny shield, and the tail, which is short, is enclosed in a hardened integument marked with a number of rings. The eyes are quite vestigial and functionless; the ear has no pinna. The limbs are short and powerful, with five digits in each, all provided with claws, those of the third and fourth digits of the fore foot being enormously developed. *Notoryctes* does not seem to form permanent burrows, but moves along under the surface through loose sand with marvellous speed. Its food consists mainly of ants captured underground.

The only Marsupials now living outside the Australian region are the Marsupials of America; and these belong, with only one exception, to a family of Polyprotodonts, the *Didelphyidæ*, or Opossums, which are not represented in Australia either in the living or the fossil condition. The one exception is a small rat-like animal—*Cœnolestes*—found in Bolivia and Ecuador. This has some claims to be regarded as a Diprotodont of the same type as the Diprotodonts of Australia: but the resemblances may perhaps be ascribable rather to convergent evolution than to near relationship. The upper teeth of *Cœnolestes* are Polyprotodont, while the lower are Diprotodont, and the skull does not show special Diprotodont features. There is no syndactylism.

The Cretaceous mammalian remains known as Triconodonts and Trituberculates may have been Marsupials: but the evidence for such a conclusion is not complete, and, in any case, it is impossible to connect them definitely with any of the living Marsupial families. The only family of recent Marsupials which has a history traceable with any degree of certainty back

to the Mesozoic period is the *Didelphyidæ* of America. Remains of Marsupials belonging to this family, or of forms regarded on good evidence as having been its precursors, occur in Cretaceous beds in North America. In the Tertiary of Europe and of North America the *Didelphyidæ* were represented by many species scarcely, if at all, to be distinguished from the living genus *Didelphys*. The European *Didelphyidæ* ranged from the Eocene through the Oligocene to the beginning of the Miocene, where they completely disappeared. In North America they became extinct in the Oligocene—those living in that country at the present day being evidently comparatively recent immigrants from the south.

In South America the Didelphyid stock appears to have been abundantly represented by small forms (*Microbiotheridæ*) in the Miocene of the Santa Cruz beds of Patagonia; but is probably to be traced much further back, to the Upper Cretaceous or lowest Eocene, on the evidence of a single fossil (*Proteodidelphys*).

In the Santa Cruz beds, in addition to a number of forms of small Marsupials (*Epanorthidæ*, *Abderitidæ*, *Cænolestidæ*), more or less nearly allied to the living *Cænolestes*, is a family of Polyprotodonts (*Sparassodontidæ*, including *Prothylacinus*), which seem to find their nearest allies in the living Tasmanian Thylacine.

In Pleistocene times Australia was populated with Marsupials, many of which belonged to genera that still survive, others to extinct genera referable to existing families. Many of both types were of gigantic size, the largest of the extinct genera being *Diprotodon*, *Nototherium*, and *Thylacoleo*. *Diprotodon*, the largest Marsupial known, was intermediate in its structure between the Phalangers and Kangaroos. All these Pleistocene forms were definitely Diprotodont or definitely Polyprotodont. *Wynyardia*, from an older horizon, seems to have resembled the South American Cænolestoids in combining Diprotodont and Polyprotodont features.

South America and Australia have thus been, so far as known, the sole centres of Marsupial evolution since the primitive Didelphyid stock became extinct in Europe and North America. And it seems to be clearly established, in view of the relationships between the Marsupial fauna, living and extinct, of South America and that of Australia, that at some period antecedent to the Pliocene, Australia and South America were in much closer connection than they are at the present day. If we leave the case of *Thylacinus* and the Sparassodonts out of account as at present undetermined, the main body of the evidence seems to point not to any *direct derivation* of the one fauna from the other, but rather to their origination in a common centre, the spreading out from this, east and west, of the two sets of primitive forms destined to give rise respectively to the American and to Australian Marsupial fauna, the eventual complete geographical separation of the two with the disappearance of the centre of origin, their arrival in South America and Australia respectively, and their further evolution there since Miocene times. Whether the primitive forms reached the original, now long submerged, centre of dispersal through South America or through Australia remains an open question. The absence of Marsupials and Marsupial remains in Asia, and the absence of any trace of Didelphyoid forms in Australian deposits would seem to point rather to the former conclusion.

(c) Non-Marsupial Mammals.

The Dingo or Native Dog (*Canis dingo*) is one of the few indigenous Mammals of Australia that are not Marsupials. The Dingo is a wild dog of about the size of a collie, which ranges all over continental Australia in the less frequented districts, and, hunting singly, or in twos and threes, or small bands of five or six, works much devastation among the flocks and herds and in the poultry runs. The Dingo is frequently reared from puppyhood by the aborigines, but never becomes really tamed or fully domesticated, and, though clever in finding and tracking game of all kinds, is not of much direct use to its masters.

Remains of the Dingo have been found mixed with the bones of extinct Marsupials—*Diprotodon*, *Nototherium*, and *Thylacoleo*—so that it is an ancient inhabitant of the country—much more ancient than Man, so far as existing evidence shows.

It is a remarkable fact that the Dingo does not occur in Tasmania, and never seems to have reached that country, since no remains of it have been found there, though it flourished on the mainland perhaps even at the time when Tasmania was not an island, but a peninsula. The survival of the Thylacine and Sarcophilus in Tasmania is doubtless due to this circumstance, since on the mainland these carnivorous Marsupials became extinct in Pleistocene times.

Other non-marsupial Mammals are a number of species of Rats and Mice (genus *Mus* of the order *Rodentia*) and other rat-like Rodents. The largest of these is a Water-rat (*Hydromys chrysogaster*), which reaches a length of some 20 inches. Very curious in their adoption of an attitude and mode of progression similar to those of the Kangaroos and Wallabies are the so-called "Jerboa" Rats. The genus to which these belong (*Conilurus*) is peculiar to Australia, though other Rodent genera—the original Jerboas—presenting a parallel modification, are distributed in Asia and Africa.

Australia also contains a considerable number of Bats of various kinds (order *Chiroptera*). The largest of these are the widely-distributed Fruit-eating Bats or Flying Foxes (*Pteropodidæ*), a family which also occurs in Africa and Southern Asia, as well as in Fiji and Samoa. These large Bats, (popularly known as "Flying Foxes" on account of their Fox-like heads and reddish fur), with a spread of wings of about 3 to 5 feet, are capable of swift and prolonged flight, and travel long distances from their diurnal haunts in remote gorges in the mountains to their feeding grounds in districts where fruit is to be obtained. During the day they rest suspended by their claws from branches of trees with the head downwards, congregating together in "camps" or "rookeries" sometimes containing thousands of individuals. At dusk they fly abroad in search of food, and often work great havoc in orchards.

Of the Insectivorous Bats some twenty-five species are represented in Australia, a few being forms of wide distribution, while the rest are confined to Australia, and in many cases to particular parts of the Commonwealth. One genus, *Rhinonycteris*, represented by a single species, seems to be confined to North and North-west Australia.

3. Birds.

The **Bird fauna** of Australia is exceedingly rich both in regard to the total number of species (about 800), the high proportion of endemic forms, and the number of interesting and peculiar groups. Here Alfred Russell Wallace may be quoted. He writes (*Geographical Distribution of Animals*. vol. I., p. 391), "The typical Australian region is almost as well defined by its birds as by its mammalia; but in this case the deficiencies are less conspicuous, while the peculiar and characteristic families are numerous and important. The most marked deficiency as regards widespread families, is the total absence of Fringillidæ (True Finches), Picidæ (Woodpeckers), Vulturidæ (Vultures), and Phasianidæ* (Pheasants), and among prevalent Oriental groups, Pycnonotidæ (Bulbuls), Phyllornithidæ (Green Bulbuls), and Megalæmidæ (Barbets), are families whose absence is significant."

No fewer than five families of birds are to all intents and purposes confined to the Australian region; and a number of others, though not so restricted, are so specially developed in it as to constitute striking features of the fauna. Of the families practically restricted to the region two of the most interesting are those of the Cassowaries (*Casuariidæ*) and Emus (*Dromæidæ*). The Australian Cassowary (*Casuarius australis*) is confined to Northern Queensland, while the Emu (*Dromæus novæ hollandiæ*) is of wide distribution in continental Australia, but the Tasmanian form (*D. diemenensis*) became extinct about half-a-century ago. Another species of Emu (*D. parvulus*) lived on Kangaroo Island, off St. Vincent's Gulf, and the bones of yet another (*D. minor*) have been found on King Island in Bass Strait. Emus have been driven back by settlement and cultivation, and have become extirpated in many districts in which they were once abundant. But they are still numerous enough in the plains and open forest country in many parts of the continent, though in order to see them in any abundance it is necessary to travel far back from the more populous centres.

This characteristic bird is almost too well known to require description. Though larger than the Cassowary, it is much smaller than the African Ostrich, the full-grown bird reaching a height of about 5 feet. The Emu and the Cassowary both differ from the Ostrich in the possession of three toes instead of only two, and in the absence of the characteristic large plumes on the wings and tail, all the contour-feathers being long, narrow, and forked. The Emus do not possess the prominent helmet-like excrescence present on the head of the Cassowary, and also are devoid of the wattles and brightly-coloured naked spaces on the neck. Emus go in pairs except after the breeding season, when a number may congregate together. They feed largely on grasses and herbage, and on roots and fruits. In spring the eggs are laid to the number of as many as forty in a hollow made in the ground or in a loosely-constructed nest. The dark-green eggs are familiar objects in the shops of dealers in curiosities.

Another peculiar family of birds almost confined to the Australian region is that of the Mound Birds or Megapodes (*Megapodiidæ*). These are birds not unlike the domestic turkey in size and general appearance, with very

* The *Phasianidæ*, as the family is now defined, are, however, represented by certain Quails (*Coturnix* and others).

strong and large feet. Unlike other birds, the Megapodes do not sit on their eggs in order to maintain the temperature necessary for incubation; but scrape together masses of earth or sand mingled with decaying vegetable matter, deposit the eggs as they are laid in depressions excavated in this mass, cover them over and leave them to be hatched by the agency of the heat generated by the decomposition of the organic matter. The young birds, as soon as they are hatched, are able to scramble out of the mound and shift for themselves. The Brush-Turkey (*Catheturus lathami*) and the Mallee Hen (*Lipoa ocellata*) represent this family, the former in the east and north-east, the latter in the south and west of the continent. Another species, the Scrub Fowl (*Megapodius tumulus*), occurs in Northern Queensland, but is found also distributed through New Guinea and a part of the Malay Archipelago. Another (*Catheturus purpureicollis*) occurs in the Cape York Peninsula. The family is not represented in Tasmania. Though characteristic of Australia, the Mound-Birds are not confined to it, extending to the east as far as Samoa, to the west as far as the Nicobar Islands, and to the north as far as the Philippines and Ladrones. The nearest known relatives of the Megapodes—structurally closely allied to them—are the Curassows (*Cracidæ*) of Central and South America.

The Pigeon family (*Columbidæ*), though not numerous when compared with their representatives in certain other regions, yet form an important element of the bird-fauna. Conspicuous among them for brightness and beauty of colouration, in which they almost rival the Parrot tribe, are the Fruit Pigeons (*Ptilopus*), mostly denizens of the tropical districts of the north. Other typical forms are the Top-knot Pigeon (*Lopholæmus antarcticus*), the little Doves of the genus *Geopelia*, the Bronze-wings (*Phaps chalcoptera* and *P. elegans*) and the Wonga (*Leucosarcia picata*).

The great development of the *Parrot* group constitutes one of the most striking and characteristic features of the Australian avi-fauna. Three families (or sub-families) are peculiar to the Australian region, and are for the most part confined to Australia itself. Conspicuous among these is the family of the Cockatoos (*Cacatuidæ*), which occurs outside Australia only in the Philippine and Sulu Islands. Of these, the White Cockatoo (*Cacatua galerita*), with yellow crest and ear-coverts, is found practically all over Australia and Tasmania, but does not penetrate to the far interior of the continent. Leadbeater's, or the Pink Cockatoo (*C. leadbeateri*), which has a red crest banded with yellow and with a white tip, and has a flush of rose colour over the head and breast, is confined to far inland districts of the continent. The widely distributed Galah or Rose-breasted Cockatoo (*C. roseicapilla*) is rose-coloured below and grey above.

Several species of the genus *Calyptorhynchus*, of varying distribution, are popularly known as Black Cockatoos on account of the prevailing blackness of their plumage. Of these, the commonest are *C. banksii*, with a red band across the tail, and *C. funereus*, with a yellow band in the same place and a yellow tuft on the ears.

The largest of the Cockatoo tribe is the Great Black Cockatoo (*Microglossus aterrimus*), which extends from Northern Queensland to New Guinea and the Aru Islands, the uniform greyish-black of whose colouring is only relieved by the red and yellow of naked patches on the cheeks. The smallest, the

Cockatoo Parakeet (*Calopsittacus novæ hollandiæ*), which is of a dark-grey with a grey and yellow crest, occurs over Australia generally, but is rare in the coastal districts. A little larger is the Gang-gang (*Callocephalon galeatum*), a grey bird with a thick crest, which is scarlet in the male, grey in the female.

The Brush-tongued Lories (*Trichoglossidæ*) are a second peculiar family of Australian Parrots extending to New Guinea, Celebes, Timor, and the New Hebrides. Of these, the best known is the gorgeously-coloured Blue-bellied Lorikeet (*Trichoglossus novæ hollandiæ*), which is of common occurrence in Eastern Australia and Tasmania, where it is often to be seen flying about in flocks and feeding on the honey of the flowers of the Eucalypts and of other trees and shrubs, and on various seeds. The prevailing colours of this brilliantly-coloured bird are blue and red, with the head and the centre of the under surface green and with a yellow band round the neck.

Belonging to a more widely distributed family is the "Budgeraga" (*Melopsittacus undulatus*), very familiar as a cage bird, little larger than a Sparrow, with green and yellow feathers bearing black markings, a yellow head, with three black spots and a band of blue on the cheek and a streak of blue in the middle of the tail. The King Parrot (*Aprosmictus cyanopygius*), which ranges over Queensland, New South Wales, and Victoria, is a large handsome Parrot with the head, neck, and under-surface brilliant scarlet, and the back and wings green.

Probably the commonest of the Australian Parrots, as well as among the most beautiful in colouration, are certain species of the genus *Platycercus* and its allies, commonly known as Parrakeets. Conspicuous among these are the Rosella (*Platycercus eximius*) and Pennant's Parakeet (*P. elegans*).

The Lyre-birds (*Menuridæ*) are restricted to the Australian continent. The Superb Lyre-bird (*Menura superba*), of New South Wales and Southern Queensland, and *M. Victoriæ* of Eastern Victoria and South-eastern New South Wales have in the adult male the ornamental lyre-like tail to which these birds owe their popular name. They are large birds of about the size of a pheasant, which, though well able to fly, live largely on the ground. They are exceedingly shy and difficult to approach, running away rapidly when approached, but if greatly startled, as by the bark of a dog, they will spring up into a low branch of a tree. The Lyre-birds are wonderful mimics, imitating very cleverly the cries of other birds, as well as any other sounds that come within their hearing.

The Honey-eaters (*Meliphagidæ*) are, perhaps, on the whole, the most interesting of all the peculiar families of Australian birds on account of their great abundance, their grace of form and movement, and the variety of their notes and cries. The *Meliphagidæ* are represented as far north as Bali, and as far south as New Zealand, but they have their head-quarters in Australia, where they find abundance of food in the honey-producing blossoms of the Myrtaceous trees (such as Eucalypts and Ti-trees), the prevalence of which is so characteristic of the vegetation. The food of the Honey-eaters does not, however, consist exclusively of honey; the small insects that frequently abound about the flowers are also devoured, and are often found to constitute a large proportion of the bulk of the contents of the crop, and in many cases various fruits also contribute to the bird's diet. The largest

members of the family, such as the Friar-bird (*Philemon corniculatus*), with its bare leathery-skinned head, and the Gill-bird (*Acanthochæra carunculata*), with its pair of appendages (" wattles " or " gills ") at the sides of the head, are of about the size of a thrush ; the smallest, such as the scarlet and black Blood-stained Honey-eater (*Myzomela sanguinolenta*) and the Spine-bill (*Acanthorhynchus tenuirostris*) are no larger than the largest humming-birds, which they resemble in their habit of inserting the long slender bill into the tube of a flower while hovering in the air.

The Scrub-birds (*Atrichornithidæ*) are also a family of birds peculiar to Australia, remarkable, like the Lyre-birds, for their power of mimicking the notes of other birds.

The Birds of Paradise (*Paradiseidæ*) are represented by their most characteristic and beautiful forms in New Guinea and the Aru Islands. In Australia they have for their representatives the Rifle-birds, for the most part restricted to Northern Queensland, and the Bower-birds, Regent-birds, Satin-birds, and Cat-birds. All of these except the Rifle-birds have the curious habit of constructing " bowers " or play-grounds, which they ornament in various ways with feathers, bones, shells, berries, lichens, and mosses. Structurally the Bower-birds are most nearly related to the sombre-plumaged Crows ; but the male attire of all of them, though much less gorgeous than that of the true Birds of Paradise, shows some tendency to brilliancy. This in the Bower-bird (*Chlamydodera nuchalis*) is limited to a band of lilac on the neck relieving the quiet brown and grey of the rest of the surface. The male Satin-bird (*Ptilorhynchus violaceus*) has a uniform coat of glistening purplish-black. The Regent-bird (*Sericulus melinus*) has its black plumage ornamented with bright orange on the head, neck, and wings. The Cat-bird (*Aeluredus viridis*) is bright green diversified by white markings, with a dash of blue on the back.

Of families (or sub-families) of birds not strictly confined to Australia, though forming important characteristic constituents of its fauna, mention should be made of the Thick-heads (*Pachycephalidæ*), the Caterpillar-shrikes (*Campephagidæ*), the Wood-swallows (*Artamidæ*), and the Weaver-finches (*Ploceidæ*). The Thick-heads, which are Polynesian as well as Australian (also Tenasserim and the Sunda Islands), are active Shrike-like birds which feed chiefly on insects. Various species of *Pachycephala* are very common birds over nearly all Australia, and are distinguished by the black band round the neck and the yellow or red breast. *Falcunculus frontatus*, the Crested Shrike, of the same family, which has also a black neck-band with a yellow breast, has a crest or tuft of feathers on the black head.

In connexion with the Shrikes mention must be made of two members of that group which are among the commonest and most conspicuous birds in all parts of Australia. These are the so-called " Magpies " (*Gymnorhina*) and " Magpie Larks " (*Grallina*). Of the Magpies there are five species, of which the most widely distributed is the Black-backed Magpie (*G. tibicen*). Protected by law on account of the good work they do in the destruction of grubs and caterpillars, which, with small lizards, form their principal food—though by no means immaculate as regards fruit and cereal crops—these handsome birds, with their striking black-and-white plumage, are very abundant even in the most closely-settled parts. Their natural song is very

musical, clear, and flute-like; they are excellent mimics, and when tamed they can easily be taught to whistle a bar or two of a simple air.

The Magpie Lark (*Grallina picata*), distributed all over Australia, except in the most arid parts, is a much smaller bird than the Magpie, which it resembles in its black-and-white plumage. It utters a monotonous sharp cry in two longish notes, from the sound of which it is in many districts known as the "Pee-wee."

Another family of Shrike-like birds specially developed in Australia is that of the *Campephagidæ* (Cuckoo Shrikes or Caterpillar Shrikes). The various species of the genus *Graucalus* belonging to this family are very common birds in the bush in most parts of Australia. They are recognisable as large birds with broad bills, with the plumage of french grey, marked about the head and throat with black, and with variously distributed white patches.

The family of the Wood-swallows (*Artamidæ*) are not by any means confined to Australia, having representatives both in India and in West Africa. The genus *Artamus* comprises half-a-dozen species, of which the most widely distributed is the common Wood-swallow (*A. tenebrosus* or *sordidus*), birds of sombre colouration, not unlike true Swallows—from which they differ widely in essentials—in general appearance and mode of flight, but with the bill long and curved instead of short and wide, and with the wings less elongated.

Mention may here be made of the Shrike-Robins or Yellow-breasted Robins of the genus *Eopsaltria*, which is peculiar to Australia, New Guinea, the Aru Islands, and New Caledonia. *E. australis*, a very tame bird, frequently seen in town gardens, is very common in New South Wales and Victoria, and allied species take its place in other parts. The Yellow-breasted Robins are usually classed with the Fly-catchers (*Muscicapidæ*).

Also familiarly known as "Robins" are a number of other small birds, notably the various species of *Petræca*, a genus which is mainly Australian in its distribution, though occurring also in New Zealand, the New Hebrides, Fiji, and Samoa. Most of the common species of *Petræca* have bright scarlet breasts. *P. goodenovii* has also a patch of scarlet on the top of the head.

The "Wrens" or "Warblers" of the genus *Malurus* (classed, like the Yellow-breasted Robins, with the Flycatchers, and confined to Australia and New Guinea) are very attractive, tame little birds, common in gardens—the adult males with brilliant plumage of blue and black, or red and black.

Though true Finches (*Fringillidæ*) are entirely wanting in Australia, there are great numbers of the nearly related family of the Weaver Finches (*Ploceidæ*), which are numerous also in Africa, Southern Asia, the Malay Archipelago, and the islands of the West Pacific. Many of these little birds are strikingly and brilliantly coloured, and, being easily captured, they are extensively kept as cage-birds. Of the eleven genera represented seven are confined to Australia.

The Kingfisher family (*Alcedinidæ*), though abundant all over the world, have their head-quarters in Australia. Those gigantic members of the group, the "Kookaburras" or "Laughing Jackasses" (*Dacelo gigas* and other

species), range all over Australia, except over the more arid parts of the interior, where there is little bird-life of any kind. Outside Australia they occur only in Southern New Guinea. The common Kookaburra (*Dacelo gigas*) extends over Queensland, New South Wales, Victoria, and South Australia. It is one of the largest of the Kingfisher tribe, with a total length of about 17 inches. A second species, *Dacelo leachii*, occurs in Queensland and in the Northern Territory; while a third, *D. cervina*, inhabits Western Australia, the Northern Territory, and the northern parts of Queensland. Kookaburras are not frequenters of streams like typical Kingfishers, and do not feed on fish. They are to be found in all parts of the bush—more especially in the prevailing open forest country—and their food consists of lizards and snakes, small mammals and birds, and large insects, such as cicadas and locusts. Their most remarkable peculiarity is their extraordinary laughing cry, usually uttered in a duet or chorus, especially frequent and noisy at sunrise and sunset. Half-a-dozen Kingfishers of smaller size also occur. The commonest of these, the Sacred Kingfisher (*Halcyon sanctus*) is to be found all over Australia, and extends to New Guinea, Sumatra, and the New Hebrides. Like the Kookaburras, it is by no means confined to the neighbourhood of water, and it does not dive into water after fish, but feeds on insects and crustaceans, small lizards, and snakes. Some of the other species are typical Kingfishers in appearance and habits, and are seldom to be seen except along the course of streams.

The Australian Birds of Prey, though numerous, present few characteristic features. The Australian Harriers, Goshawks, Sparrow Hawks, Eagles, Sea Eagles, Kites, Falcons, Kestrels, Ospreys, and Owls are not, save in small particulars, different from the corresponding birds of other regions, and belong to the same or to nearly related genera. Vultures are not represented. The largest Australian Bird of Prey is the Wedge-tailed Eagle, or "Eagle-hawk" (*Aquila* or *Uroaetus audax*), which is rather larger than the European Golden Eagle. This is by no means a rare bird; in fact, its numbers sometimes render it so formidable to the young lambs in pastoral districts that poisoning is resorted to, and large numbers are destroyed. On the other hand, the Wedge-tailed Eagle does a good work in destroying many rabbits. Unlike the Golden Eagle the Wedge-tailed Eagle is by no means averse to feeding on dead animals which are in a well-advanced stage of putridity.

4. Reptiles.

Of the **Reptiles** Australia possesses but a poor fauna so far as the Tortoises (*Chelonia*) and Crocodiles (*Crocodilia*) are concerned, while the Lizards (*Lacertilia*) and Snakes (*Ophidia*) are much more numerous. The Tortoises all belong to a family, the *Chelydidae*, occurring elsewhere only in South America. The genus *Chelodina* comprises three species in Australia and one in New Guinea. Of the Australian species *C. longicollis*, the Long-necked Tortoise, inhabits the fresh waters of all the southern part of continental Australia.

There are two species of Crocodile, both confined to the Tropics (Northern Queensland). One of these (*Crocodilus porosus*) which lives in estuaries and readily ventures out to sea, is a widely distributed Indian and Malayan

species, which reaches an immense size in some of the rivers of North Queensland. The other (*C. johnstoni*), which does not reach a greater length than 6 or 7 feet, is also confined to rivers of the tropical north, but does not go down into salt water.

The Lizards of Australia are very numerous, but present few marked characters. Geckos and Skinks, generally distributed in other regions, are represented by a number of genera and species. Of the Skinks one characteristic form, which is distributed over the Australian continent, is the Shingle-back or Stump-tailed Lizard (*Trachysaurus rugosus*), the only species of a genus which does not occur outside Australia. This was one of the few Australian animals noticed by Dampier in his famous visit to Western Australia in 1699. Another much commoner member of the Skink family is the large sluggish smooth-scaled Blue-tongue (*Tiliqua scincoides*). The commonest, small, long-tailed Lizards, with habits like those of the European species of *Lacerta*, are also members of the Skink family (various species of *Lygosoma* or *Hinulia*).

Allied to the Skink tribe is a family of snake-like Lizards, the *Pygopidæ*, entirely confined to Australia and Tasmania with, perhaps, New Guinea. They are limbless, or practically limbless, Lizards often mistaken for Snakes, and found in all parts, living in holes in the ground or under stones, and coming out to feed usually in the evenings. The largest of these snake-like forms are about 2 feet long.

One of the families of Lizards best represented in the Australian fauna is that of the *Agamidæ*, which contains a number of characteristic forms. One of its most remarkable members is the Frill Lizard (*Chlamydosaurus Kingi*), of Queensland and northern and north-western Australia. The most striking feature of this Lizard, which grows to 3 feet in length, is the wide frill-like flap of skin on either side of the neck, which the animal erects when alarmed, by means of long rib-like extensions of the hyoid apparatus. The Frill-lizard when pursued runs in a semi-erect position on the hind limbs with the fore limbs clear of the ground; but soon turns at bay, spreading out the frill to its full extent, and opening its mouth widely, at the same time emitting a peculiar hissing sound which adds to the alarming effect of its attitude.

Belonging to the same family are the various species of *Amphibolurus* or "Dragons," a genus confined to Australia. These are small-scaled Lizards with extremely long narrow tail, and frequently with crests or rows of spines along the back. One of the largest is the widely-distributed Jew Lizard (*A. barbatus*), which reaches 21 inches in length, and owes its specific name to the possession of a fringe of spines ("beard") behind the ears and on the lower jaw. A striking ally of these is the Water Dragon (*Physignathus lesueuri*), which may be 3 feet in length, and has an elongated compressed tail, and a prominent crest along the neck and back. The Water Dragon is very common along the banks of creeks in the whole of Eastern Australia. The genus occurs also in New Guinea and neighbouring islands, in Siam, and in Cochin China.

The most grotesque of all the Agamidæ is *Moloch horridus* of Western Australia, which, with its spiny head and body, has a curious superficial

resemblance to the misleadingly-named "Horned Toads" of North America, members of a family of Lizards, the Iguanidæ, not represented at all in Australia.

The largest of all the Australian Lizards, and one of the best known and most widely distributed, is *Varanus gouldi*, the Lace Lizard, often termed "Iguana" or "Goana," which sometimes reaches a length of 5 feet. This Lizard has nothing to do with the true Iguanas, which are an essentially American group; but belongs to the family of the Monitors (*Varanidæ*), which are of very wide occurrence. It is a long-tailed, long-necked Lizard, blackish brown above, with yellow spots on the body and yellow rings round the tail, yellow below. The Lace Lizard lives much in trees, which it climbs in search of the eggs and nestlings of birds. It frequently raids fowl-runs for the eggs and young chicks. But it will devour any animal, living or dead, that comes in its way.

Australia possesses numerous *Snakes*, some venomous, some non-venomous. Among the venomous kinds none belong to the Viper family, all being members of the Elapine section of the family *Colubridæ*, a group of snakes of wide distribution, occurring not only in Australia, but over Africa, Southern Asia and the islands of the Malay Archipelago, and Central and South America. One of the commonest of these is the Black Snake (*Pseudechis porphyriacus*), which occurs all over Australia, except in the north and in Tasmania. The Black Snake, which may reach a length of upwards of 6 feet, is commonly found in swampy districts or along the banks of creeks and rivers. It is readily recognised by the red under surface. The Copper-headed Snake (*Denisonia superba*) (the popular name of which is derived from the colour of the head in the young animal) chiefly frequents swamps in Tasmania, Gippsland, and the Alps of Southern New South Wales. The Tiger Snake (*Notechis scutatus*), of about the same size as the Black Snake or rather smaller on the average, is also widely distributed on the mainland in comparatively dry country, and occurs also in Tasmania. This, the deadliest of the Australian venomous snakes, derives its popular name from the numerous dark bands crossing the back. The Brown Snake (*Diemenia textilis*), also very venomous, is also of widespread occurrence. It is uniformly brown above in the adult condition, whitish below. The so-called Death Adder (*Acanthophis antarcticus*) is found in sandy localities nearly all over Australia, and occurs also in New Guinea. It is a small thick snake, rarely as much as 3 feet long, with fine mottling of brown, reddish, and yellow on the upper surface, with darker cross bands. The horny spine at the end of the tail, which gives its name to the genus and is often supposed to be of the nature of a sting, is perhaps used as a fulcrum in locomotion.

Of the non-venomous snakes the largest by far are the Variegated Pythons (*Python variegatus*), commonly known as Carpet Snake and Diamond Snake. Of the two varieties of this species the Carpet Snake is the larger, not infrequently reaching a length of 12 feet, while even larger specimens are occasionally met with. Its popular name is derived from the irregular pattern of dark markings on the pale-brownish ground colour of the upper surface. The Diamond variety is darker, almost black, with a yellow spot on each scale and diamond-shaped groups of yellow spots at irregular intervals. The Carpet Snake occurs over Australia generally, but is absent in the south

of Victoria and in Tasmania. The Diamond Snake occurs only in parts of New South Wales and Queensland. The food in both cases consists of the smaller mammals and of birds.

Among the other non-venomous snakes are the Fresh-water Snakes (*Tropidonotus picturatus*) of Eastern Australia, and the Green Tree Snakes, of which there are two species—*Dendrophis calligaster*, of Northern Queensland, and the widely distributed *D. punctulatus*. The harmless little burrowing Blind Snakes of the family *Typhlopidæ* are numerous. The family is of wide distribution in tropical and semi-tropical countries.

5. Amphibia.

The **Amphibian** fauna of Australia is characterized by an abundance of Frogs and Toads, and by a somewhat singular absence of the tailed Newts and Salamanders, represented abundantly in other regions, and of the snake-like Cæcilians (*Gymnophiona, Apoda*), which occur in other warm countries. None of the many species of Frogs belong to the genus *Rana*, to which the common English frog belongs, with the exception of a single species found in the Cape York Peninsula in the extreme north of Queensland—a district which shows many other anomalies in its fauna due to migration from the north. The majority of the Australian Frogs are either Tree-frogs (*Hylidæ*), or belong to a family, the *Cystignathidæ*, which has no European representatives, but contains many South American forms. Thirteen out of the sixteen genera that occur in Australia are peculiar to it. The family *Engystomatidæ*, well represented in America, Africa, Madagascar, India, the Malay Archipelago, and New Guinea, has been recently recorded from the Cape York District. Not only are Frogs very abundant in all the habitable parts of Australia, but they extend also into Central Australia, a region which for long periods is quite rainless. Here Spencer found several species, all similar to those occurring in regions of higher rainfall, but showing in their habits and mode of life a special adaptation to the dry conditions under which they live for the greater part of the year.

The frog most commonly seen in most parts of Australia is the web-footed, brilliantly-coloured, green and golden Bell Frog (*Hyla aurea*), which, though a tree-frog in structure, is rarely found in trees or even bushes, but lives in or about swamps, water-holes, and streams. Equally common in many parts, though not so frequently seen except at the breeding season owing to its nocturnal and burrowing habits, is a cystignathid frog *Limnodynastes peronii*. Another species of Hyla, the large bright-green *Hyla caerulea*, is not uncommon in many parts. The largest Australian frog of all is the Barred River Frog (*Mixophyes fasciatus*), which occurs along rivers and creeks in Eastern Australia.

Perhaps the most interesting of the Amphibia are the small cystignathid frogs and toadlets, such as *Crinia signifera*, *Hyperolia marmorata*, and others, which are to be found lurking under stones in moist places or in holes and crannies in soil or rock. The most brilliantly-coloured of these, as of all the Australian Amphibia, is the little *Notaden bennetti*, with its rich pattern of bright yellow, red, green, black, and white.

The spawn of Australian frogs is, in most cases, very similar to that of the English frog (*Rana temporaria*), except that in some forms it is not deposited

in large masses in water, but is laid in small clumps under stones or tufts of herbage in the neighbourhood of water. The stages of the development are also closely similar to the corresponding stages in *Rana temporaria*, except that, at least in the common species of *Hyla* and *Limnodynastes*, there is a great reduction in the system of external gills.

6. Fresh-Water Fishes.

The "Burnett Salmon" (*Neoceratodus forsteri*) is, from an evolutionary point of view, the most interesting and important of the fresh-water **Fishes** of Australia. Extremely restricted in its range, it occurs only in the Burnett and Mary Rivers of Queensland. But, though found living in no other part of the world, *Neoceratodus* is represented by teeth closely similar to those of the living form in Triassic and Jurassic beds of Europe, in the Trias of India, in the "Karoo" (Upper Trias) of South Africa, in the "Cretaceous" of Patagonia, in the Permian of Texas and in the Upper Jurassic of Colorado. The fossil teeth in question were known and had been given the name of *Ceratodus* long before the living fish was discovered. *Ceratodus* (or *Neoceratodus*) is thus an animal of great geological antiquity, and has had in past times a very wide, well-nigh cosmopolitan, geographical range.

Though not unlike an ordinary typical fish, such as a salmon, in general shape, *Ceratodus* is at once seen to present some marked peculiarities. The paired fins are of a peculiar leaf-like shape, and are supported by a limb-skeleton which is unlike that of any other living animal, and has been supposed by some comparative anatomists to be the most primitive known form of limb-support. The general surface is covered with large scales, and there is an operculum or gill-cover like that of an ordinary bony fish. But, though *Neoceratodus* has gills like those of fishes in general, it also has a lung and breathes air; and its heart and system of blood-vessels are very specially modified in comparison with those of other fishes in connexion with this double mode of respiration.

Often popularly confused with the Burnett Salmon (on account perhaps of the same native name being sometimes applied to both) is a very different, but also interesting, Queensland fish, the "Barramunda" (*Scleropages leichardti*). The chief interest of the Barramunda is connected with the peculiar distribution of the family (the *Osteoglossidæ*) to which it belongs. Of the four living genera of this family *Scleropages* extends from the rivers of Northern Queensland to Sumatra, Banka, and Borneo: *Arapaima* (one of the largest of fresh-water fishes) inhabits South America (Brazil, the Guianas): *Osteoglossum* has a similar range: while *Heterotis* is African, inhabiting the Niger, the Nile, the Senegal, and the Gambia. Since, however, fossil representatives have been found from the Eocene both of the United States and of England, the *Osteoglossidæ* are not exclusively southern forms, but are to be regarded as forming one of the many groups which, formerly more widespread, have in recent times become more or less completely restricted to the great southern land-masses.

The little fishes commonly called "Minnows," and, when larger, "Native Trout" (species of *Galaxias*), common in nearly all fresh-water streams in extra-tropical Australia, also belong to a family (the *Galaxiidæ*) with a remarkable distribution. There are only two genera—*Galaxias* and

Neochanna. *Neochanna* is a marine fish confined to New Zealand. Of *Galaxias*, some 22 species occur in Australia, Tasmania, New Zealand, and the Auckland and Chatham Islands: seven species occur in southern South America, Tierra del Fuego and the Falklands: one inhabits the streams of Cape Colony: one (*G. attenuatus*) is found not only in the southern extremity of South America, with Tierra del Fuego and the Falkland Islands, but also in Tasmania, New Zealand, and the Chatham Islands. These facts relating to the distribution of the genus *Galaxias* in general, and in particular the last-mentioned fact of the occurrence of the same species on opposite sides of the Pacific, have often been adduced as strong evidence in favour of the view that a land connexion existed between South America, Australia, and New Zealand at a not very remote period. But this view has had to be modified since it has been pointed out that, as was stated as long ago as 1872 by Captain F. W. Hutton, *G. attenuatus* goes down to the sea to spawn, and since it has been found to occur in large numbers in the sea at the Falkland Islands. Moreover, another species, which would seem to be a marine one, has been found at the Chatham Islands in the stomach of a Merganser.

A fresh-water fish very common in the rivers of Tasmania, where it is commonly known as the "Cucumber-mullet," and an allied species, the "Grayling," occurring sparingly in Victoria, New South Wales, and Queensland, belong to another family, the *Haplochitonidæ*, forming a link between Australia, New Zealand, and South America. Of the *Haplochitonidæ*, which is an exclusively fresh-water family, there are only two genera—*Haplochiton* and *Prototroctes*. The former contains two species occurring in Chili, the southernmost extremity of South America, Tierra del Fuego, and the Falkland Islands, and a third in Tasmania. *Prototroctes*, including the Cucumber-mullet and Grayling above mentioned, has three species altogether, one in New Zealand, one in Queensland, New South Wales, and Victoria.

English Brown Trout and American Rainbow Trout have been introduced into a number of the rivers, and have done very well; but the only indigenous member of the Trout family (*Salmonidæ*) is a little fish called Smelt (*Retropinna retropinna*), which is widely distributed in Australia, and occurs also in New Zealand.

Among other less remarkable Australian fresh-water fishes a number of families are represented. Several members of the Herring family live habitually in the rivers, or ascend them occasionally. Such is the Fresh-water Herring (*Potamalosa novæ-hollandiæ*), which occurs plentifully in the Hawkesbury, the Clarence, the Richmond, and other rivers of the east coast. Several fresh-water members of the Catfish family (*Siluridæ*) also occurs and are remarkable, like many allied forms, for the care taken of the eggs, The common fresh-water Catfish (*Copidoglanis tandanus*), which occurs throughout the far-spreading Murray River system, and is valued for food, belongs to a genus which extends into Asia. Eels (*Anguilla reinhardtii*) are common in all the eastern waters. Of the members of the Perch-like family *Serranidæ*, the best known is the so-called Murray Cod (*Oligorus macquariensis*), a valuable food-fish which grows to a large size, and is common in the Murray River system, as well as in the Clarence and Richmond.

The only Lamprey occurring in Australian rivers is a species of *Geotria*—a genus that is found also in New Zealand and in Chili.

7. Mollusca of the Land and the Fresh Water.

The terrestrial and fresh-water **Mollusca*** of Australia are numerous and varied. In the dense and moist forests of tropical Queensland the greatest development is obtained. Here the typical Australian genus *Thersites* presents about 50 species, most being large and showy shells, usually banded and globose. In the family *Acavidæ* are included the giants of the fauna. *Panda falconeri* is an ovate shell about 3½ inches long, while the coils of the flatter *Pedinogyra cunninghami* are almost 3 inches in diameter. The carnivorous snails are represented by a handsome brown *Rhytida*, with fine thread-like ribs above and smooth beneath.

Approaching Torres Strait the influence of New Guinea appears in *Papuina*, a genus of arboreal habits. Here, too, the operculate division assume importance. To this belong *Pupina*, a glossy shell with transverse slits to the aperture, living among drifts of dead leaves, and *Helicina*, a genus of almost world-wide distribution. Among the hills of Central Australia occurs a desert fauna of modified *Xanthomelon* and *Thersites*. Like environment has moulded these to a superficial resemblance to the snail shells in arid regions of Africa or America.

Slugs are not abundant, but in Tasmania and Victoria is the small hump-backed *Cystopelta petterdi*, on the east coast *Aneitea graeffei*, a large cream-coloured slug, with a pink diamond on its back; and in the Queensland tropics, the prismatic *Atopos*.

Widespread over all the continent are several genera of *Endodontidæ*, small discoidal shells with delicate radiating riblets.

The fresh-water mollusca are less peculiar than the terrestrial. Familiar forms which reappear are *Sphærium*, *Pisidium*, *Corbicula*, *Limnæa*, *Planorbis*, *Ancylus*, *Bythinia*, *Vivipara*, and *Melania*. Widespread through every pool and creek is the genus *Isidora*. At first this was mistaken for *Physa*, but is now found to be really related to *Planorbis* despite its unlike shell. More than 60 species of this very variable genus have been named, but this probably exaggerates the number of forms.

About a score of river mussels are referred to *Diplodon*, a southern genus extending to New Zealand and South America. *D. novæ-hollandiæ*, from the coastal streams between Brisbane and Newcastle, has a peculiar ornament of radiating nodules.

Tasmania has an interesting series of fluviatile shells. In the lakes occur *Ancylastrum*, the largest known fresh-water limpet. Another limpet, *Gundlachia*, whose shell develops a second chamber, is of sporadic occurrence. Some small gasteropods, *Petterdiana* and *Littoridina*, which live in running streams, appear to be of southern origin and akin to South American types.

In *Solenaia rugatus* and *Physopsis jukesi*, the Northern Territory possesses two exceptionally isolated forms, the first of an Asiatic, the second of an African genus.

8. Crustaceans.

The largest and most conspicuous of the fresh-water **Crustacea** of Australia are the Crayfishes. There are few streams or stationary bodies of fresh water, however small, in extra-tropical regions, that do not contain

* For the following brief account of the Mollusca I am indebted to Mr. Chas. Hedley.

Crayfishes; and they are found to occur even in arid Central Australia wherever there is a creek bed that occasionally contains running water. By far the most widely-distributed Crayfish in continental Australia is one, the Two-keeled Crayfish (*Cheraps bicarinatus*), which in general appearance is not very unlike the common European Crayfish (*Astacus* or *Potamobius fluviatilis* or *astacus*), differing chiefly in the character of the rostrum and the chelæ. The Australian form, however, reaches larger dimensions, though in this respect there is a wide difference between specimens from different localities. *Cheraps bicarinatus* is more especially an inhabitant of dams and waterholes or of pools in the more sluggish streams, and excavates innumerable burrows in the banks, often doing serious damage in this way to mud or clay embankments of storage dams and reservoirs.

In clear-running streams the prevailing Crayfish is the common Serrated or Spiny Crayfish (*Astacopsis serratus*), with numerous varieties, some of which may prove to be of specific rank. In the larger rivers, such as the Murrumbidgee and the Murray, these Crayfishes reach a large size, assuming dimensions as great as those of the largest of the European Sea-lobsters; and even in very small creeks specimens of great size are occasionally met with. The Spiny Crayfish, like the two-keeled form, is an active burrower, and is able by taking refuge in deep burrows with a little water at the bottom to survive periods of prolonged drought.

In Tasmania the Crayfishes are represented by two species, which are nearly allied to *Astacopsis serratus* of the mainland. One of these (*A. franklinii*), which occurs in the northern rivers of the island State, is the largest Crayfish known, even exceeding in size the largest of the Spiny Crayfishes of continental Australia.

Quite peculiar to Australia is a group of Crayfishes belonging to the genus *Engæus*, which do not ordinarily live in streams or pools, but inhabit during the day-time the interior of burrows excavated sometimes along the banks of streams, sometimes merely in swampy ground which may be at some distance from any running stream. These small Crustaceans, with their feeble powers of locomotion and their reduced abdomen, seem to have taken a short step in the direction of the modification undergone by the Hermit-crabs.

In Western Australia three species of Crayfishes are known—*Chœraps quinque-carinatus*, *C. tenuimanus*, and *C. preissii*, all very distinct from those of Eastern Australia.

The Australian Crayfishes all belong to a family, the *Parastacidæ*, which is exclusively southern in its distribution, taking the place in the south occupied by the family *Astacidæ* (or *Potamobiidæ*) in the north. Their nearest allies are thus not the English Crayfishes, but other members of the *Parastacidæ*—the Crayfishes of South America (*Parastacus*), New Zealand (*Paranephrops*), and Madagascar (*Astacoides*).

Extremely common in creeks, at least in Eastern Australia, are minute transparent shrimp-like Crustaceans, which, so far as they have been examined, have been found to belong to a species, *Xiphocaris compressa*, originally described from Japan, and since found in Norfolk Island.

If we leave *Engæus*, the Land-crabs, and *Phreatoicopsis* out of account, the only terrestrial Crustaceans are the Wood-lice and Pill-bugs (*Isopoda*),

and the Hoppers (*Amphipoda*). The latter (*Talitrus sylvaticus*) occur from near the sea-level to a high elevation on the Southern Alps.

Land-crabs, in the strict sense of the term, are confined in Australia to the far north and the islands of Torres Straits. But River-crabs of the genus *Geothelphusa* occur far up the Darling River and its tributaries, and were found by the Horn Expedition in waterholes along the creeks in Central Australia. When the creeks and rivers dry up, the River-crabs, like the Crayfishes, burrow into the banks, and by burying themselves in moist clay may escape desiccation.

A little fresh-water Lake-crab (*Hymenosoma lacustris*) occurs in Lake Colac, in Victoria. The same species is found in the North Island of New Zealand, and also in Norfolk Island.

An order of the higher Crustacea—the *Anaspidacea*—fossil (marine) representatives of which are known from Permian and Carboniferous strata in Europe and North America, is confined at the present day to Tasmania (*Anaspides* and *Paranaspides*) and Victoria (*Koonunga*). The Anaspids are little Crustaceans of a Shrimp-like appearance, which inhabit fresh-water, the Tasmanian forms occurring only at high elevations (2,000 feet and upwards). Though in many respects resembling the Shrimps and Crayfishes, the *Anaspidacea* differ from them in the complete absence of the cephalo-thoracic shield or carapace, and in the series of plate-like gills attached to the legs.

A family of fresh-water *Isopoda*—the *Phreatoicida*—was, until recently, regarded as peculiar to Australia, including Tasmania, and New Zealand. Very recently a species of the type-genus, *Phreatoicus*, has been found in South Africa. Most of the Australian and Tasmanian forms occur at high elevations. One genus, *Phreatoicopsis*, is terrestrial and not aquatic.

Of fresh-water Amphipods there are several species of *Gammarus* occurring both in Victoria and New South Wales; two species of *Chiltonia* have been described from Lake Hindmarsh, Victoria, and species of *Hyalella* and *Neoniphargus* also occur.

While the higher Crustacea (*Malacostraca*) of Australian fresh-waters contain such a number of interesting characteristic forms—the Crayfishes and Antispidacea in particular—the lower Crustacea (sub-class *Entomostraca* of the older classification) are not, so far as known, in any way specially remarkable. The giants of the group, the Phyllopods, *Apus*, *Lepidurus*, and *Triops*, occur, under favorable conditions, in enormous numbers in the inland districts. The Brine-shrimp (*Artemia*) has been found both in New South Wales (neighbourhood of Sydney) and in Victoria, and a peculiar Australian genus, *Branchinella*, of the same family, is represented by three species occurring in fresh or brackish water in most parts of Australia. The Bivalved Phyllopoda (*Limnadidæ*) occur very abundantly in Australia, and are represented by several genera, including *Eulimnadia*, *Limnadopsis*, *Paralimnadia*, and *Cyzicus* (*Estheria*).

The much smaller *Cladocera* or " Water Fleas " are represented by species of the cosmopolitan genus *Daphnia*, also by species of *Moina*, *Macrothrix*, *Lynceus*, and others.

The Australian fresh-water *Copepoda* and *Ostracoda* have not received so much attention as the *Phyllopoda*. But, of the former order, species

of the genera *Cyclops* and *Diaptomus* have been described, and of the latter a number of species of *Cypris*, and also species of *Candona* and *Notodromus*.

9. Insects.

The **Insecta** of Australia are too vast an assemblage to be dealt with in a brief summary: but the following are a few leading points:—

Among the *Orthoptera* the Cockroaches (*Blattidæ*) are represented by both native and introduced forms. Of those which occur habitually in houses, the indigenous *Periplaneta australasiæ* has become largely replaced by the American *Periplaneta americana*. There are a number of "wild" species, wingless for the most part, and usually of large size, to be found most frequently lurking in crevices in rotten timber and under fallen logs and stones. Most of these when molested discharge a foul-smelling secretion from glands at the end of the abdomen. One of the commonest is *Polyzosteria limbata*, a wingless dark-brown Cockroach with yellow lines round the terga.

The *Mantidæ*, or "Praying Insects," with their innocent appearance and predaceous habits, form an important element of the Australian insect fauna. The most conspicuous of these are species of the genera *Archimantis*, *Orthodera*, and *Tenodera*, some over 4 inches in length.

The *Phasmidæ* or Leaf- and Stick- Insects are probably more numerous in Australia than in any other region of the earth's surface. The protective mimetic features, which in many cases cause these curiously modified insects to resemble their usual surroundings so closely as to render difficult detection by insect-eating birds or lizards, consist mainly in the form of the body itself being in many cases narrow and elongated so as to resemble the appearance of a twig of the plant on which they feed, and in the presence of foliaceous green appendages on the limbs and body, bearing a close resemblance to the leaves. Some of the Australian *Phasmidæ* are the largest of existing insects, with a length of as much as 12 inches.

Of the Grasshoppers and Locusts there are many genera and species, some winged, some wingless, some with long feelers, some with short. The term "Locust" is applied to any member of the Grasshopper family that has the peculiarity of occasionally increasing enormously in numbers, so as to give rise to great swarms which move about the country destroying the vegetation as they go. Several of the Australian species swarm in this way and assume for the time the character of "Plague Locusts." One of these is the Lesser Plain Locust (*Chortoicetes pusilla*), a comparatively small insect about an inch in length. Another is the Larger Plain Locust (*C. terminifera*). A third is the Yellow-winged Grasshopper (*Locusta danica*), very common everywhere, which sometimes causes devastation in Queensland.

The most remarkable-looking member of the family is the so-called Mountain Grasshopper (*Acridopeza reticulata*), which is very unlike a normal Grasshopper in appearance, with its short, rounded, blue, white, and red body, and its peculiar oval concavo-convex elytra.

Of the Crickets (*Gryllidæ*) there are a number of species of Field Crickets —sometimes occurring in swarms—and a Mole Cricket (*Gryllotalpa coarctata*), found practically all over Australia.

Among the *Neuroptera* special mention may be made of the Ant-lions (*Myrmeleonidæ*) and the Dragon-flies (*Odonata*). The Ant-lions are numerous, most of the described species being referred to the genus *Glenurus*. *G. pulchellus* is the commonest species along the coast. The largest is *G. fundatus*, which is found along the coast of Queensland.

The Australian *Odonata** are as remarkable in their way as most of the animal groups of the same continent. There is a rich autochthonous fauna, chiefly located in the south-western corner, along the eastern coast and ranges, and in Tasmania. A tropical invasion, mainly of *Libellulinæ*. descends along the Queensland coast into New South Wales. The remarkable sub-family *Corduliinæ* is represented in Australia by about forty species, roughly one-fifth of the world's total! Of these, *Hemicordulia tau* and *H. australiæ*, are common nearly everywhere, and the former may possibly be taken in August. The peculiar species of *Synthemes* must be sought for later in the season, mostly at high elevations. On the Blue Mountains two very archaic species are to be obtained, viz., *Petalura gigantea* and *Austropetalia patricia*. The larva of the former tunnels in mud. The latter is very closely allied to a group of Chilian species, and has no other close relatives at all. In August a few common Dragon-flies begin to appear, and the following may be met with:—At Perth, *Austrolestes annulosus*, *A. analis*, *Xanthagrion erythroneurum*, *Anax papuensis*, and *Æschna brevistyla*; the same species at Adelaide; at Melbourne, the same except *A annulosus*, which is replaced by *A. cingulatus* and *A. leda*: at Sydney, the same together with *Argiolestes icteromelas*, *Austroagrion cyane*, *Ischnura heterosticta*, *Ischnura aurora*, *Austrolestes psyche*, *Orthetrum caledonicum*, *Diplacodes bipunctata*, and *D. hæmatodes*. Full-fed larvæ of most of these species can be easily obtained during August.

Termites, or White Ants, as they are popularly called, abound in all parts of Australia, and some of them, such as the little *Termes (Coptotermes) lacteus*, do much damage to wooden structures. Many of the species build mounds or termitaria of comminuted wood with, in some cases, an investment of clay, constructed usually over an original tree-stump. These, in the case of some of the tropical species, are of great size—as much as 18 feet in height in the case of *Eutermes pyriformis* of tropical Queensland.

Of the *Hymenoptera*, one of the families specially developed in Australia is that of the Saw-flies (*Tenthredinidæ*), of which there are a large number, all belonging to genera—*Perga*, *Pterygophorus*, and others—peculiar to Australia. The blackish larvæ of *Perga* are frequently to be seen clinging in great masses to branches of Eucalypti, on the leaves of which they feed.

Another largely-represented family is that of the *Chalcididæ*, or Parasitic Wasps, minute forms, most of which deposit their eggs in the eggs, larvæ or pupæ of other insects, or in the galls produced by Coccids.

Of similar habits are the still smaller *Proctotrypidæ*, some of which appear to be of economic value owing to the fact that they are destructive to various scale and other insects injurious to fruit-trees.

Also destructive, and on a larger scale, to other forms of insect life, such as caterpillars of moths and butterflies, in which they deposit their eggs, are the Ichneumons (*Ichneumonidæ*), of which there are many in Australia, though comparatively few have been described.

* For the information on the Odonata I am indebted to Mr R. J. Tillyard.

The Flower Wasps (*Thynnidæ*), which are only represented outside Australia on the west coast of South America, and, by a few species, in Asia and the Pacific Islands, are very numerous on such flowering shrubs as the Ti-trees (*Melaleuca*, *Leptospermum*). About three-fourths of the described species of *Thynnidæ* are Australian.

The well-known Mason Wasps (*Eumenidæ*), which are solitary forms with the habit of constructing nests of clay, often on a verandah, or even in the interior of a house, and storing them with caterpillars, are common in all parts of Australia.

The true (social) Wasps (*Vespidæ*), which construct nests of a parchment-like material, are represented in Australia by two genera, *Ocaria* and *Polistes*, the genus *Vespa*, though of wide distribution and occurring as near as Java, being absent.

Of the true Bees (*Apidæ*) there are a large number, but the genera *Apis* and *Bombus* do not occur. The Carpenter Bees of the genus *Lestis*, some of which make their nests in the interior of dead flower-stems of grass trees (*Xanthorrhœa*), are peculiar to Australia. The stingless native Honey-bees of the genus *Trigona*, which are widely distributed over Australia, construct irregular wax combs in cavities in Eucalypts and other trees, and store them with a dark-coloured honey. The Leaf-cutting Bees, which construct the cells of their nests out of pieces cut from the leaves of plants, are represented by a number of species of *Megachile*—a genus found in most parts of the world.

The Ant Family (*Formicidæ*) is represented by an immense number of genera and species. Of these the most characteristic are the large Ants of the genus *Myrmecia*, commonly known as Bull-dog Ants, which are sometimes as much as an inch or more in length and have a very poisonous sting; these are confined to Australia. Honey-pot Ants in which, as in a North American and an African species, certain of the workers of the community serve as store-houses for honey, occur in Central Australia.

The House-flies which swarm about dwellings in the cities of Australia in summer are identical with the common House-fly of England (*Musca domestica*), a species almost universal in its distribution. A somewhat smaller fly (*Musca vetustissima*) is the pest fly of the bush. A fly (*Stomoxis calcitrans*) very like the House-fly, common out of doors and sometimes coming into houses, inflicts a sharp bite when it settles on the skin, and is extremely troublesome to horses and cattle. This, like the House-fly, is of almost world-wide distribution. Of the Blow-flies, the commonest species are *Anastellorhina augur*, with a brown abdomen having a blue stripe down the centre, and *Calliphora villosa*, which has the abdomen covered with yellowish or brownish hairs, and a somewhat smaller species of the same genus, *C. oceanicæ*, with a steely-blue abdomen, is also very common. Several of the species of Blow-flies have become very formidable pests, which have assumed the character of a yearly-increasing menace to the pastoral industry, their maggots, bred in the wool of the sheep, producing sores which often eventually cause death.

Australia is particularly rich in Gall-gnats (*Cecidomyidæ*), the larvæ of most of which burrow in leaves and other parts of plants, producing frequently definite galls or other malformations.

Over 50 species of Mosquitoes have been recorded from Australia, most of them species of *Culex*. Several of them are of cosmopolitan range, or have been introduced from other countries. The Mosquitoes commonest in houses are *Culex albo-annulatus*, *C. fatigans*, and *C. marinus*, the last able to breed in salt water. The genus *Anopheles*, to which belong the Mosquitoes that transmit malarial fever, is represented by several species; and at least one species occurs of the genus *Stegomyia*—the yellow-fever transmitting genus.

Though not so rich in Butterflies as South America, Australia yet holds a high place in that respect among the zoological regions. Thus, while only 68 species occur in Great Britain, a recent catalogue of the Australian species gave a total of 330. The largest and most brilliantly-coloured forms are tropical. Fritillaries, Emperors, Admirals, Blues, Whites, Yellows, Skippers, and Swallow-tails are all well represented. *Belenois java*, one of the whites, in some seasons comes down from the interior to the coast in such enormous swarms as to constitute a veritable plague.

Of the many families of Moths perhaps two of the most characteristic are the Case-moths and the Cup-moths, the former on account of the peculiar sheath of tough silky material which the larva weaves about itself, with fragments of leaves or sticks woven in, and the latter because of the vase-shaped cocoons of a parchment-like substance in which the eggs are enclosed. Included among the other families are Butterfly Moths (*Uraniidæ*), Day Moths (*Agaristidæ*), Ringed Moths (*Syntomidæ*), Burnet Moths (*Zygænidæ*), Hawk Moths (*Sphingidæ*), Wood Moths (*Hepialidæ*), Tiger Moths (*Arctiidæ*), Brown Tails (*Liparidæ*), Silkworm Moths (*Bombycidæ*), Loopers (*Geometridæ*), Cutworm Moths (*Noctuidæ*), Leaf Rollers (*Pyralidæ*), and Bell Moths (*Tortricidæ*).

The Cutworm Moths are of economic importance, owing to the damage frequently done by their larvæ ("Plague Caterpillars," "Army Worms") to crops of all kinds. The Bugong Moth (*Agrotis infusa*) occasionally appears in enormous swarms in the coastal districts.

Of the *Coleoptera*, or Beetles, some 10,000 Australian species have been described, and, as there are a number of families which have not been fully investigated, there can be no doubt that this seemingly immense multitude falls far short of the total. One of the best developed and most characteristic of the families is that of the *Buprestidæ*, or Jewel Beetles, of which only ten species occur in Great Britain. These large and often brilliantly-coloured metallic Beetles are most abundant on flowering shrubs in the coastal districts of extra-tropical Australia. *Stigmodera* is the most characteristic genus. It is peculiar to Australia, and some 240 species have been described. The *Stigmoderæ* are large Beetles, some as much as 2½ inches in length, of rich and varied metallic colouration.

Of the *Hemiptera* perhaps the most characteristically developed, and certainly the most conspicuous, family is that of the Cicadas (*Cicadidæ*), the chorus of whose shrill cries rings out during summer from every shrub and tree. Of the many Australian species of Cicadas some—more particularly those inhabiting the coastal districts—are large and handsome insects. *Thopha saccata* has a reddish-brown body about 2 inches long with a stretch of wings of 5 inches; it is common in all the southern coastal districts and

along the east coast as far north as Brisbane. The bright green *Cyclochila australasiæ* is even commoner in New South Wales; and a third common form is the Black Cicada, *Psaltoda mœrens*, belonging to a genus peculiar to Australia. Another large Cicada very common in Eastern Australia is *Abricta curvicosta*, a reddish-brown form, with a silvery down over the surface.

Another characteristic family of *Hemiptera* is the *Psyllidæ*, or "Lerp" insects, the larvæ of many of which secrete a shell-like protective covering of lerp scales, or of soft woolly matter, while others produce galls on leaves.

Of the Australian Coccids the most remarkable group is the *Brachyscelinæ*, or Gall-making Coccids, the larvæ of which form galls on the twigs and leaves of many native plants. These are practically confined to Australia, the only instance of a Gall-making Coccid occurring elsewhere being a single species found in Mexico.

10. Scorpions and Spiders.

Of the **Arachnida** the *Scorpionida*, or Scorpions, are not uncommon in Australia; but none of them are large, and the number of species is small, and all of them belong to three of the six recognised families—the *Buthidæ*, the *Scorpionidæ*, and the *Bothriuridæ*. Of the last-named family, *Cercophonius* is a genus confined to Australia.

The *Spiders** of Australia are very numerous, and belong to a great number of families. Reference can be made here to only a few of the most interesting forms. One of the best-represented groups is that of the Trap-door Spiders, of the family *Avicularidæ*, of which upwards of sixty Australian species have already been described. Of the family *Hypochilidæ*, which comprises only three species, one species (*Ectatosticta troglodytes*) occurs in caves in Tasmania, a second in North America, and a third in China. Of the *Argiopidæ*, one of the most interesting and beautiful is *Argiope ætherea* (*A. regalis*), which occurs not only all over Australia, but in New Guinea and many of the islands of Torres Straits. This brightly-coloured Spider is popularly known as the "St. Andrew's cross Spider" on account of the cross-shaped stabilimentum which it weaves into the middle of its orbicular web.

Also included in the *Argiopidæ* are two widely distributed species, *Poecilopachys bispinosa* and *Celænia excavata*, both of which closely resemble the droppings of birds. Another striking member of the same group is *Dicrostichus magnificus*, which is a large and brilliantly-coloured Spider with a peculiar branched crest or protuberance on which the eyes are situated.

The family *Thomisidæ*, or "Crab Spiders," comprises a number of interesting species, one of which—*Saccodomus formivorus*—lives in trees and preys on tree-haunting ants. The *Salticidæ*, or "Jumping Spiders," are very numerous, and comprise some remarkable forms, among which may be mentioned the brilliantly coloured *Saitis volans* and *S. splendidus*, both of which have an extended lateral flattened abdominal integument which is folded round the spider when at rest and thrown open when it leaps.

* For information on the Spiders I am indebted to Mr. W. J. Rainbow.

11. Centipedes and Millepedes.

The Australian **Myriopoda** are extremely numerous, and all, or nearly all, of the known families are represented, though some of the smaller and more obscure groups have not been fully investigated. Of the *Diplopoda* the largest and most conspicuous are the Millepedes of the family *Iulidæ*—cylindrical, vegetable-feeding Myriopods with numerous segments, each segment bearing two pairs of legs. These are very common about rotten timber, under fallen logs, and under stones, the elongated body coiled up into a spiral when at rest.

The family *Cambalidæ*, which in regions outside Australia are chiefly distributed in Polynesia, in India, and Madagascar, is represented in Western Australia by four peculiar genera—*Dinocambala*, *Podykipus*, *Atelomastix*, and *Samichus*.

The *Polydesmidæ*, also with a cylindrical body, but with comparatively few segments, each with a lobe or keel on its upper surface, is represented by several peculiar genera (*Antichiropus* and others), and a number of species.

The *Polyzoniidæ*, small worm-like forms with reduced appendages and sucking mouth, has several representatives of the genera *Orsilochus* and *Siphonotus*.

Of the *Chilopoda* the Centipedes of the family *Scolopendridæ* comprise the largest of the Myriopods, with flattened bodies and 21 or 23 pairs of legs. Of these, a considerable number of species have been described from all parts of Australia. Among the commoner and more widely-distributed forms are the very variable *Scolopendra morsicans*, which is common all over Australia, and is almost cosmopolitan in its range, *S.* (*Rhombocephalus*) *læta*, and *Ethmostigmus rubripes*, the largest of the Australian Centipedes, which occurs also in the South Sea Islands.

The *Lithobiidæ*, which are comparatively short, with only fifteen segments, are represented by several genera; and the greatly elongated many-segmented *Notophilidæ* are also represented, though perhaps only by introduced forms.

The long-limbed, short-bodied *Scutigeridæ*, which differ from the rest of the *Myriopoda* in the possession of compound eyes and the presence of air-sacs, are represented by at least one species, *Allothereua maculata*, which not infrequently comes into town houses.

The order *Symphyla* is represented by at least one species of *Scutigerella*, a small insect-like Myriopod with twelve segments, with a pair of parapodia on each in addition to the legs, and with only one pair of breathing pores, which are situated on the head.

Of the aberrant order *Pauropoda* there is no record.

The Onychophora are well represented in Australia by about five species distributed over all the States, with the apparent exception of South Australia and the Northern Territory: but they do not seem to be in abundance anywhere. The five described species are referred to the two genera, *Ooperipatus* and *Peripatoides*.

12. Earthworms, Leeches, etc.

Of the **Earthworms** the family *Cryptodrilidæ* is so specially well represented in Australia that it might be said to have its head-quarters there,

five genera of the family out of a total of about sixteen being peculiar to Australia, or only slightly represented elsewhere. Some of the Cryptodrilids, such as *Megascolides,* are of gigantic size—up to 5 feet in length.

The fresh-water allies of the Earthworms are very numerous, and almost all the families are represented, though only a few have been studied. *Enchytræids* are common both in water and damp earth. *Chætonotus, Dero, Nais, Aeolosoma,* and *Tubifex* also occur—the last-named present sometimes in enormous numbers in muddy creeks. The *Phreodrilidæ* is the most characteristic Australian family. It is represented elsewhere in South America, in Kerguelen, and in New Zealand and South Africa. In Australia there are at least two peculiar genera, *Phreodriloides,* found in the Blue Lake on Mount Kosciusko, and *Astacopsidrilus,* two species of which constantly live on the surface of fresh-water Crayfishes.

Australia possesses two peculiar genera of **Land Leeches**—*Philæmon,* confined to Australia and Tasmania, and *Geobdella,* to Australia and New Guinea. Of fresh-water Leeches the commonest and the largest is *Limnobdella australis,* the common Australian Medicinal Leech. Other fresh-water Leeches are species of the widely distributed genera *Glossiphonia* (or *Clepsine*) and *Herpobdella* (or *Nephelis*), and one each of the genera *Dineta* and *Semilageneta,* which are peculiar to Australia.

Of fresh-water **Polyzoa** the commonest—abundant in Queensland, New South Wales, and South Australia—is the familiar European species *Plumatella repens. Plumatella princeps,* which has also been found in these three States, is a cosmopolitan form. Another species of the same genus—*P. aplinii*—which occurs in New South Wales and Victoria, appears to be peculiar to Australia; and the same holds good of a species of *Lophopus*—*L. lendenfeldi*—which has only been found at Parramatta, and of *Fredericella australiensis,* which occurs abundantly at the Pott's Hill Reservoir, of the Sydney Water Supply. A species of *Alcyonella* and one of *Fredericella* have also been found in the neighbourhood of Sydney.

Land Planarians are particularly abundant in Australia, though, since the genera represented are all pretty widely distributed in the other zoological regions, they do not present any peculiarly Australian features. The commonest of them about the towns is an introduced species, *Placocephalus kewensis,* which also occurs in England, in Germany, and Cape Colony, as well as in Samoa. Of the others, about 50 species have been described, including 35 of *Geoplana,* 4 of *Rhynchodemus,* 5 of *Artioposthia,* and 4 of *Platydemus.* Very little is known of the allied **Fresh-water Triclads,** though they are abundant enough—the only described forms being a few Western Australian species of *Planaria.* And the same has to be said of the fresh-water *Rhabdocœles,* though superficial descriptions have been published of a few of them, and a still more limited number have been more thoroughly studied.

Mention may here be made of an order of Planarian-like Flat-worms, the **Temnocephaloidea** (usually placed with the Trematodes), since they are specially numerous and varied in Australia. These live on the outer surfaces and sometimes in the branchial cavities of Crayfishes and other fresh-water Crustaceans. Though Temnocephoids occur in other regions (New Zealand, the Malay Archipelago, South America, India, Madagascar), they apparently

reach their maximum development in Australia as regards numbers and variety.

Only one species of Land *Nemertine* (*Geonemertes australis*) has so far been found in Australia; it occurs in Victoria, New South Wales, and Tasmania.

No fresh-water **Medusæ** are known to occur. There seems to be only one species of fresh-water **Polype** described (*Hydra hexactinella* or *H. oligactis*), and only one fresh-water Zoophyte of the colonial type (*Cordylophora whiteleggei*). About ten species of fresh-water **Sponges,** belonging to several genera, have been described. They have been found in all parts, with the exception of the Northern Territory and the northern parts of Queensland and of Western Australia.

CORRIGENDA

Page 256, line 52, for "*Aechna*" read "*Aeschna*"
" 257 " 21, for "*Tremanotus*" read "*Trematonotus*"
" 257, " 41, for "*Fenestallidæ*" read "*Fenestellidæ*"
" 258, " 10, for "*Rhachopteris*" read "*Rhacopteris*"
" 262, " 29, for "trilolites" read "trilobites"
" 266, " 32, for "*Rhachopteris*" read "*Rhacopteris*"
" 266, " 43, for "*Streptorhyncuhs*" read "*Streptorhynchus*"
" 270, " 45, for "*Glossoptris*" read "*Glossopteris*"
" 275, " 41, for "*Macrotæniopteris*" read "*Macrotæniopteris*"
" 275, " 43, for "*Cladophebis*" read "*Cladophlebis*"
" 276, " 26, for "*Tremanotus*" read "*Trematonotus*"
" 277, " 9, for "*Beyrichia endothyra*" read "*Beyrichia. Endothyra*"
" 277, " 32, for "*Tremanotus*" read "*Trematonotus*"
" 277, " 42, for "*Cladophebis*" read "*Cladophlebis*"
" 282, " 10, for "*gregarious*" read "*gregarius*"
" 282, " 11, for "*Archaomene*" read "*Archæomæne*"
" 282, " 27, for "Killak" read "Kirrak"
" 282, " 37, for "*Macrotæmopteris*" read "*Macrotæniopteris*"
" 286, " 47, for "*Pentrune*" read "*Penteune*"
" 287, " 41, for "*Meiolonia*" read "*Meiolania*"
" 291, " 31 and 35, for "*Olenollus*" read "*Olenellus*"
" 291, " 34, for "*Huenolla*" read "*Huenella*"
" 294, " 34, for "*Spiriferina dielasma*" read "*Spiriferina. Dielasma*"
" 294, " 36, for "senilia" read "senilis"
" 294, " 40, for "*Cyrtina syringothyris*" read "*Cyrtina. Syringothyris*"
" 295, " 12, for "*Ptycomphalina*" read "*Ptychomphalina*"
" 295, " 39, for "spirifeidæ" read "spiriferidæ"
" 296, " 9, for "*Plagiophyllum*" read "*Pagiophyllum*"
" 296, " 39, for "*Cladophebis*" read "*Cladophlebis*"
" 297, " 3, for "*Cladophebis*" read "*Cladophlebis*"
" 297, " 21, for "*Alithopteris*" read "*Alethopteris*"
" 298, " 4, for the table as given, read :—

McCoy and Chapman	Hall and Pritchard.	Tate and Dennant
5. Pleistocene		
4. Upper Pliocene (Chapman)	4. Werrikooian (Pleiocene)	Pleistocene (Tate) Pliocene (Dennant)
3. Lower Pleistocene ..	3 Kalimnan (Miocene)	Miocene
2. Miocene	1. Janjukian (Eocene)..	? Oligocene (Tate) Eocene (Tate and Dennant)
	Aldingan (Eocene in part)	Eocene in part
1. Oligocene.. ..	2. Balcombian (Eocene)	Eocene

Page 298, line 30, for "*Carcharodon, Megalodon*" read "*Carcharodon megalodon*"
" 301, " 24, for "*antiaustralia*" read "*antiaustralis*"
" 306, last sentence should come after first sentence on page 305
" 307, line 26, for "osmiridian" read "osmiridium"
" 309, " 43, for "melanite-hauy-syenite" read "melanite-hauyn-syenite."

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CHAPTER VII.

THE GEOLOGY OF THE COMMONWEALTH.

By T. W. Edgeworth David, C.M.G., D.Sc., F.R.S., Professor of Geology in the University of Sydney.

SYNOPSIS.

1. Introduction.

An observer taking a bird's-eye view of Australia and Tasmania would see the great island continent carpeted nearest the coast with strips of dark-green gum forest on the east, south-east, and north, and again in the south-west of Western Australia, with an outlying strip upon the Flinders Range, of South Australia. The remainder would present a curious patchwork, partly of the dull green sage bush, salt bush, and other salsolacious herbs of the steppes, the grasses of the savannahs, and the dark-green mulga scrubs, partly of patches of red and brown sands of desert areas dotted with oases which fringe the worn-down stumps of ancient inland mountains.

White specks in numbers would be conspicuous in this patchwork of green and red and brown wherever the saline surfaces of dead lakes, or "playas," reflect the sunlight, or where the highlands of New South Wales and Victoria are white with snow, except in late summer. To the south-east the emerald isle of Tasmania, the south coast of South Australia, the south-east coast of Victoria, and in places, the inland uplands of tropical Queensland would appear jewelled with live lakes. To the north the great island of New Guinea would loom large with its alpine ranges whitened with snow; its mountain uplands, where visible through breaks in the mist, showing verdant grassy slopes encircled by sombre pines and cypress. Lower still would be seen the dense dark-green jungle of the coastal plains.

Australia is well known as the home of the eucalypt, and this most characteristic tree is in itself an epitome of the climatic conditions of Australia in late geological time.

The most primitive types of our eucalypts develop their leaves with the broad surfaces horizontal, pointing to a time when there was no need to take special precautions to conserve moisture. On the other hand, in the vast majority of eucalypts, the leaves hang with their broad surface vertical, so as to offer as little evaporating surface as possible to the sun's rays. These eucalypts in their early stages of growth show the atavistic tendency to develop their leaves with the broad surfaces horizontal.

This adaptation of plant to climate in such a way as to enable the plant to resist drought connotes a former better rainfall, and this in turn suggests a former higher relief for the Australian land surface inducing a more abundant convectional rain, and thus the eucalypts record the most recent climatic changes of Australia, and prepare us for those evidences of peneplained and downward warped mountain chains with recently uplifted coast lines, which harmonize with its large disintegrated drainage system. This disintegration of the drainage is again in harmony with the shallow wide-bottomed valleys choked with the rock *débris*, with the vast red soil plains, and with the kunkars, laterites, "pindan, ironstones," and porcellanites, so characteristic of the interior of Australia, as of all countries where the rainfall is scant and the evaporation great. But that these inland areas of low rainfall are not without those blessings of aridity, the rich plant foods which have accumulated during the sabbatical periods of drought, is proved by the extension inland, through methods of dry farming, of the wheat belt, and the consequent contraction of the central waste areas.

Australia, including Tasmania, has an area of 2,974,600 square miles: it is just a trifle larger than the United States of America, and twenty-five times as large as the United Kingdom. As it extends over 33° of latitude, its climate varies from tropical to cool temperate.

2. Coastal Physiography.

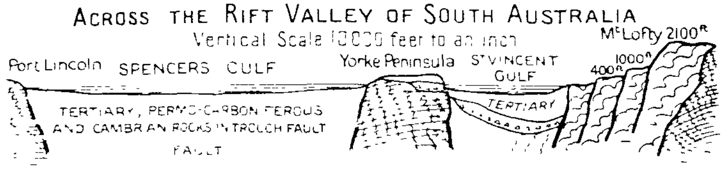
A glance at the map (Pl. III.) explains some of the chief reasons for the shape of the Australian coast.

The chief coastal indent—the Gulf of Carpentaria—is to be correlated with strong tectonic lines, approximating to a meridional direction which determined the position of the northern end of the Cretaceous Basin. The dominant folds in Arnhem Land, on the west side of the Gulf, are parallel to its shore line, the folds in the Palæozoic rocks of the Cape York Peninsula are approximately meridional, with a very heavy downthrow at the trough of the Little River coal-field. The southern shore of the Gulf seems related to the W.N.W., E.S.E fold axes which run through the Etheridge and Gilbert gold-fields.

The Great Australian Bight again appears to be of tectonic origin, lying between the old fold mountains (recently block-faulted) of the Mount Lofty and Flinders Ranges, near Adelaide, and the vast peneplain of Western Australia, with its worn-down folds, shaped in plan like an inverted S. (See Pl. III.).

The two deep indents—Spencer Gulf and St. Vincent Gulf—are clearly "Senkungsfelder," the southern end of the Great Rift Valley which extends by way of Lake Torrens (92 feet above sea level) to Lake Eyre (about 60 feet below sea level). (See Fig. 1.)

FIG 1. SKETCH SECTION. (Suggested by works of Walter Howchin)
ACROSS THE RIFT VALLEY OF SOUTH AUSTRALIA



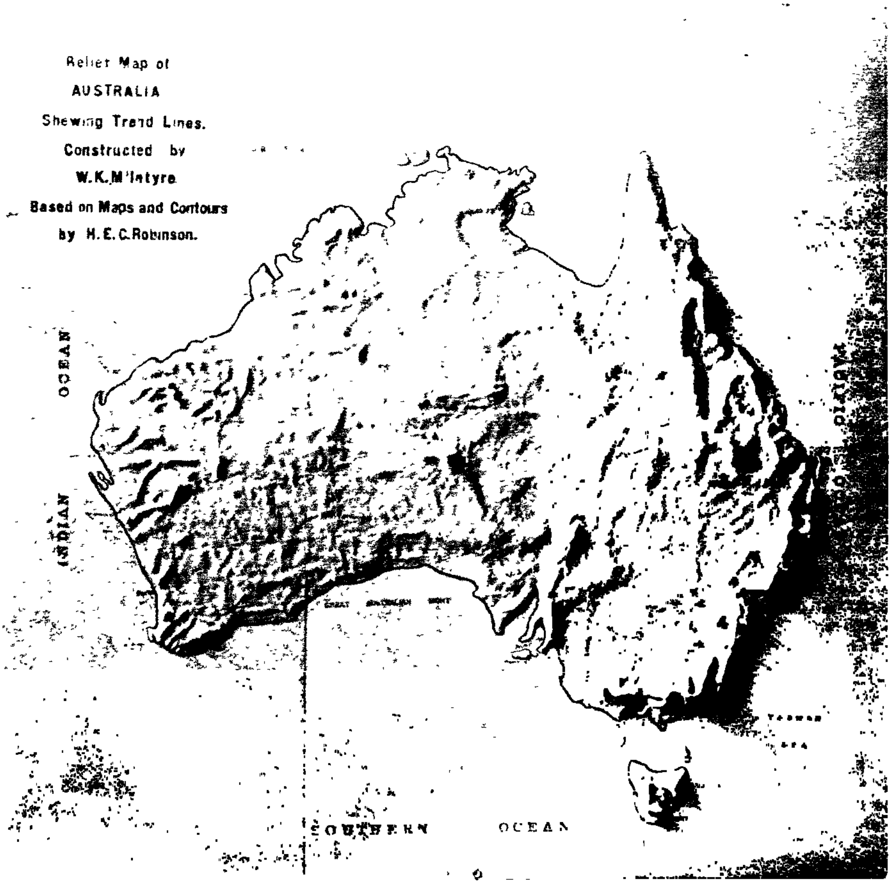

Relief Map of
AUSTRALIA
Shewing Trend Lines.
Constructed by
W.K.M'Intyre
Based on Maps and Contours
by H.E.C.Robinson.
INDIAN OCEAN
SOUTHERN OCEAN
TASMAN SEA

PLATE I

PLATE II.

RELIEF MODEL OF AUSTRALIA AND TASMANIA, by W. K. McIntyre,

showing the horst of Tasmania, with its high peaks of diabase sills, to left of the fault trough of Bass Strait. Mt. Kosciusko, 7,300 feet, is just to the right of the right hand of the two small black shadows on the north side of Bass Strait, at the knotting point between the east and west trend lines of the southern coast of Victoria, and the more or less meridional trend lines of the east coast of Australia. To right of Kosciusko the Hunter Geocol is seen in front of and midway between the sharp peaks of the Warrumbungle Mountains on the left, and the Nandewar Ranges on the right. Further to the right the dark patch crossing the range represents a narrow tongue of Jurassic sediments joining the large dark area of the main artesian basin to the plain of Jurassic and Cretaceous rock, also showing dark, lying along the middle area of the east Australian coast line. Further to the north-east is the steep-to rockland coast of north-eastern Queensland, rising in the Bellenden-ker Range to 5,428 feet. To the left of the main dark patch, showing the Central Artesian Basin, and between it and Tasmania the smaller dark patch indicates the Cainozoic plains of the Darling-Murray Rivers. Beyond the mouth of the Murray River is the long horst of the Mt. Lofty and Flinders Ranges, with Kangaroo Island at the extreme left, and the rift valley of Spencer's Gulf just above it. Above Spencer's Gulf is shown a narrow ridge, assumed to be formed of Palæozoic, or older rock, separating the Central Artesian Basin from the crescent-shaped dark area to the left, the Bight coastal plain, occupied by Older Tertiary marine limestones overlying Cretaceous glauconite sandstones. It is possible that there is a narrow gap in this ridge making the main Cretaceous basin continuous with this coastal sub-artesian basin. To the right of and above the ridge is the sharp peak of Pre-Cambrian rock of Mt. Woodroffe, in the Musgrave Ranges.

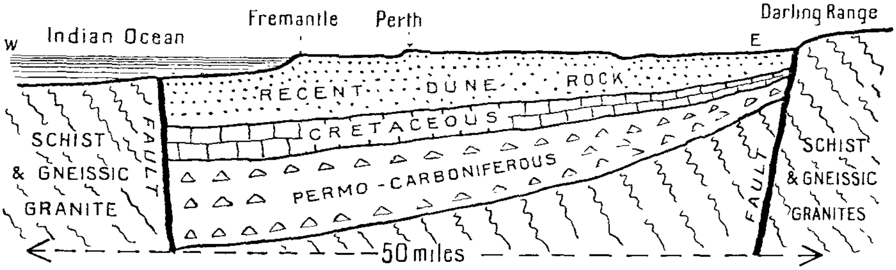
The rest of the continent, chiefly Pre-Cambrian, is a vast peneplain, from 1,000 to 3,000 feet above sea-level. In the extreme south-west are block faulted mountains, the Stirling Range, &c. Along the extreme western coast is a narrow coastal plain, scarcely visible on the model, from its present point of view, with the two dark promontories of Sharks Bay, near its northern end. Further to the right is the deeply dissected region of Pilbara, much block-faulted. Still further to the right, and immediately above the eastern half of the Tertiary basin of the Great Bight, near the north-west coast, is the depressed area of the Great Desert Artesian Basin, of Permo-Carboniferous age.

Bass Strait, as shown by the geological evidence, is another rift valley crossing the older "grain" of the country, and so is Torres Strait.

A positive movement of the strand line by about 200 feet would re-unite Tasmania and Australia, and a positive movement of only about 100 feet would re-unite Australia and Papua. The latter might easily result from a negative movement of the ocean of about the above amount, such as probably occurred towards the culmination of the latest Ice Age, when the sea level in temperate and sub-tropical latitudes was probably 100 feet lower than at present, owing to the locking up of water to form the great ice sheets.

The features of Cape Leeuwin and Cape Naturaliste are certainly due to a heavy coastal trough fault just to their east, which in that south-west part of Western Australia has determined for a great distance the trend of the western coast line. (See Fig. 2.)

FIG. 2.—Section across the Great Trough Fault of Western Australia (vertical scale 8,000 feet to an inch) from data suggested by A. Gibb-Maitland, F.G.S.



Hobson's Bay, or Port Phillip, south of Melbourne, is probably on a meridional rift valley.

The Hunter Valley and port of Newcastle are situated on a N.W. to S.E. rift valley.

The whole of the Queensland coast coincident with the Great Barrier Reef for 1,200 miles N.N.W. from Rockhampton, owes its trend to powerful downthrows to the east, perhaps compensating for the epeirogenic movement of land to the west.

The trend of the east and west shores of Tasmania is parallel to axes of folding.

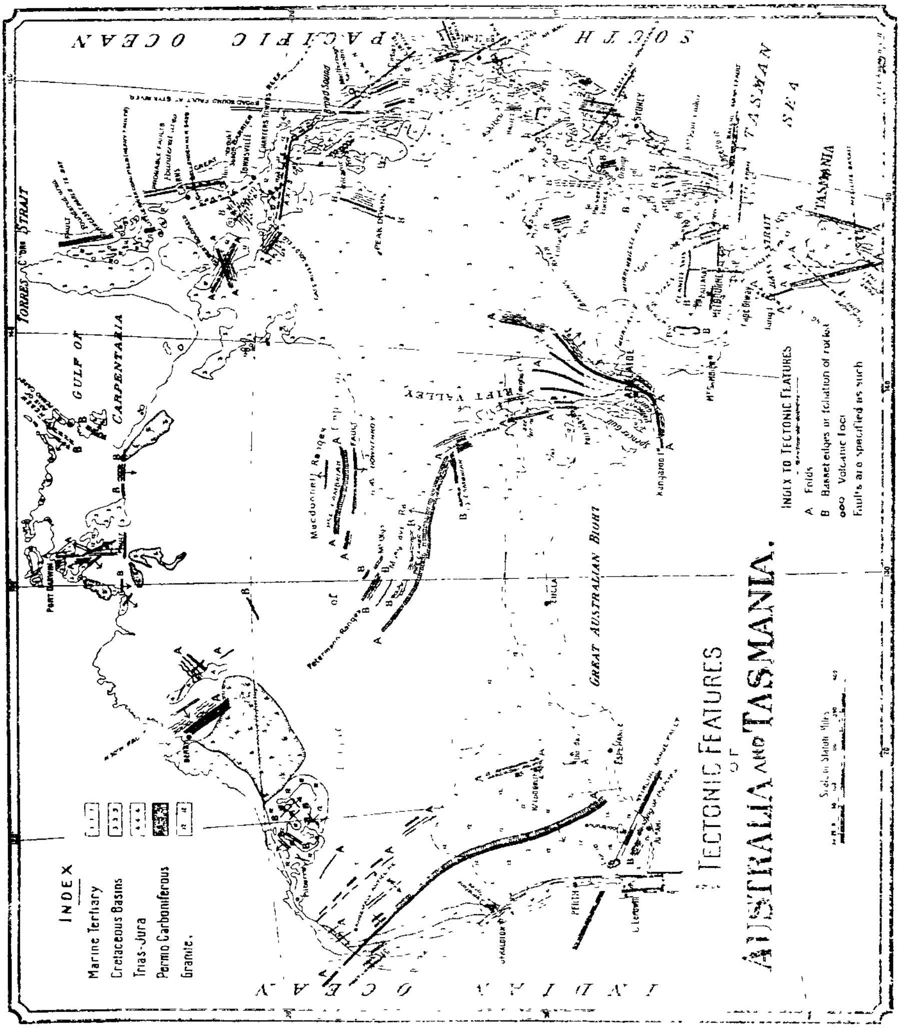
It is obvious that the south coast of Australia, as well as the whole of its north and north-west coast, is of an Atlantic type. On the contrary, the south-west coast of Western Australia, the east and west coast of Tasmania, and the north-east coast of Queensland are as regards their trends of a Pacific type. The south-east coast of Australia does not appear to be either wholly Atlantic or wholly Pacific. The term sub-Pacific has been suggested for it. As regards its geological structure, the Australian coast at Fremantle, near Perth, consists of a recent dune rock cemented by lime derived chiefly from remains of mollusca and *Lithothamnion*. Numbers of artesian wells sunk in this rock near Perth yield copious supplies of artesian water. Cretaceous rocks have been penetrated there at about 1,000 feet below sea-level. Similar calcareous dune rock forms the coast at Cape Northumberland, in South Australia, at Warrnambool, in Western Victoria, and at Sorrento, on the east side of the entrance to Port Phillip, but so far has not been proved to carry artesian water.

From Cape Naturaliste to Cape Leeuwin the coast is formed of recent dunes resting on granite, while towards Albany a deeply indented coast of granite makes its appearance with dunes lodging in the hollows. Further eastwards, near Cape Riche, is a small basin of marine Jurassic rocks, while near Cape Arid, the coast is marked by the Recherche Archipelago, mostly formed of ancient crystalline rocks. East of Cape Arid to Fowler's Bay, in the direction of Eyre's Peninsula, the coast line is formed of nearly perpendicular cliffs, up to 250 feet in height, with a further gentle rise inland towards the Nullarbor Plains, of about 290 feet. At the base they are formed of white chalky rock with *Gryphæa* and layers of flints, the whole capped by polyzoal and molluscan limestones. At present the whole of this series is attributed to some time between Eocene and Lower Miocene. At about 900 feet below sea level, at the Madura bore, to the west of Eucla, the Tertiary limestone rests on a thick series of Cretaceous greensands with a well preserved marine fauna. No rivers exist anywhere along this 500 miles of unbroken coast line, nor indeed along the further eastward extension of the coast for another 500 miles from Fowler's Bay to the head of Spencer's Gulf. As the rocks inland are mostly almost horizontal porous Tertiary limestones, there is no surface run-off of the rain water, but it sinks in swallow-holes to tortuous subterranean tunnels, by which it is discharged at the foot of the sea cliffs, or between tide marks or out at sea, as in the case of the catavothra of Greece. From Fowler's Bay around the headlands of Eyre's Peninsula and lower end of Spencer's Gulf, the coast line is formed partly of Tertiary sediments, partly of pre-Cambrian schists, gneiss and granite. The last-mentioned is well seen in the north and south Neptunes at the entrance to St. Vincent's Gulf. A plain of erosion along the coast, part of a block faulted peneplain, crosses Yorke's Peninsula to the east side of St. Vincent's Gulf, and extends to the western side of the Mount Lofty Ranges. This coast is formed partly of Post Pliocene flood loams, containing remains of *Pallimnarchus pollens,* partly of richly fossiliferous Tertiary marine limestones, partly of Permo-Carboniferous glacial beds, and partly of the highly folded Cambrian series with their glacial beds. For general interest and variety this part of the coast line is probably unequalled elsewhere in Australia. The strand line has here recently undergone an emergence of 12 feet, and Port Adelaide and Port Wakefield are built on the land thus naturally reclaimed. This evidence of recent 12 feet emergence can be traced around the greater part of Australia, and is probably due to a eustatic negative movement of the ocean. Kangaroo Island is formed of Cambrian rocks, capped by Tertiaries and basalt at its east end. The Cambrian rocks continue along the coast east of Backstairs Passage to the mouth of the Murray River at Port Elliott. In the reclaiming, as the result of positive movement of the strand line, of the Tertiary basin which extends far inland from this part of the coast, the rivers Murray and Darling have become engrafted.

From the mouth of the Murray to Cape Northumberland, the coast line is mostly formed of loose dune sand or consolidated dune sand like that of Cape Northumberland. The dune rock rests either on marine Tertiaries, or on recent alluvials of the Murray basin, or on small inliers of granite.

Inland from Cape Northumberland are the recently extinct volcanoes of Mount Schanck, Mount Gambier, etc. From Cape Northumberland to east

PLATE III


TECTONIC FEATURES
OF
AUSTRALIA AND TASMANIA.
INDEX
Marine Tertiary
Cretaceous Basins
Trias-Jura
Permo Carboniferous
Granite.
INDEX TO TECTONIC FEATURES
A Folds
B Basket edges or foliation of rocks
ooo Volcanic foci
Faults are specified as such
PACIFIC OCEAN
INDIAN OCEAN
SOUTH
TASMAN SEA
TORRES STRAIT
GULF OF CARPENTARIA
GREAT AUSTRALIAN BIGHT
RIFT VALLEY
BASS STRAIT
TASMANIA
PORT DARWIN
SYDNEY
MELBOURNE
PERTH
ESPERANCE
EUCLA
TOWNSVILLE
Macdonnell Ranges
Petermann Ranges
Spencer Gulf
Kangaroo I.

of Warrnambool the coast is similar with occasional outcrops of Tertiary sediments capped by basaltic lava, until the Otway coast is reached. This is formed of freshwater Jurassic strata, in places containing small seams of coal.

East of the dune rock of Sorrento, the Victorian coast is formed of Tertiary rocks and older basalt; then of the Gippsland coal measures in which the claw of a dinosaur and teeth and scales of ceratodus have lately been discovered; then at Cape Liptrap the cliffs are partly Silurian and partly Ordovician slaty rocks, while at Wilson's Promontory they are of granite. Beyond Corner Inlet there follows to the north-east the long stretch of sands deposited in the slack water between the southerly flowing East Australian current, and the current flowing easterly out of Bass Strait. This sand has engrafted many of the rivers, and formed the Gippsland Lakes. Probably the reclamation has been helped by a positive movement of the strand line. At Gabo Island and Cape Howe granites form a rück-land coast, which continues with the addition of Ordovician, Silurian, and Devonian sediments to Moruya and Milton.

To the north of Milton, the coast partakes more of the nature of a forland coast and a distinct coastal plain is developed, formed of the sediments of the Permo-Carboniferous and Triassic basins. This continues north for over 200 miles to Port Stephens. In its deeply indented estuaries, harbors, and drowned valleys, such as those of Jervis Bay, Port Hacking, Botany Bay, Port Jackson, Broken Bay, Port Stephens, etc., and in the entire absence of marine Tertiary deposits, this part of the strand line shows evidence of recent negative movement. From Jervis Bay to Wollongong, the strata in the sea-cliffs are rich in Permo-Carboniferous marine fossils, while those of Bulli and the cliffs 100 miles north, extending to Newcastle, show frequent coal seams, and abound especially near Newcastle in Permo-Carboniferous fossil plants.

From Port Stephens to near Grafton, the coast is mostly of an indented type, with drowned valleys between hills coming close to the coast, with numerous bar harbors, and with a narrow coastal plain fringing Carboniferous, Devonian, and probably Ordovician strata. An outlying part of an immense belt of serpentine, intrusive into Middle Devonian radiolarian rocks, touches the coast at Port Macquarie. From the Clarence River to the Richmond there is a forland coast of Jurassic coal measures, the Clarence basin. A low indented rückland coast, again of Ordovician strata, cherts, tuffs, and quartzites, and capped by alkaline basalts and acid pitchstones stretches from Ballina to near the mouth of the Brisbane River. A forland coast in part Jurassic, stretches from the Brisbane River to Gladstone. The interesting volcanic rocks, comendites, riebeckite trachytes together with alkaline andesites and basalts form conspicuous domes and sugarloaves a short distance inland from the coast, which is there fringed with dunes, the largest in Australia, up to 800 feet high. At Maryborough and Great Sandy Island marine Cretaceous rocks outcrop with a basin of productive coal (the Burrum Basin, the only basin of Cretaceous coal worked within the Commonwealth) immediately overlying them. From Gladstone to Cape York there is a remarkable coast, chiefly of the rück-land type, with mountain ranges from 2,000 feet up to over 5,000 feet high (Bellendenker, 5,428 feet)

coming mostly close to the coast line, and having high islands like Hinchinbrook, which rises to an altitude of 3,560 feet, close inshore. This part of the coast and coastal shelf is so heavily faulted and studded with small islands, which have survived the block faulting, as to deserve Suess' title of "panzer-horst." In places there is a coastal plain, as at the Jurassic (or Cretaceous (?) coal-basin of Broadsound, at Port Mackay, and to north-west and south-east of Townsville North), in others the old rocks, chiefly Carboniferous strata, with *Lepidodendron* and *Phillipsia*, or Devonian rocks with massive coral and stromatoporoid limestones, both systems intruded by granites, form bold cliffs and headlands. This remarkable part of the coast line is opposite to the Grand Canal of Australia which runs between the Great Barrier Reef and the main land. These high coastal hills are obviously part of the Old Main Divide, its eastern slope with nearly all the easterly flowing rivers being faulted eastwards under the Barrier. This coast terminates in granite capped with the horizontal Upper Cretaceous desert sandstone, which forms Cape York. Throughout this great stretch of coast from Cape Howe to Cape York, a distance of 2,150 miles, marine Tertiary deposits are wholly unknown. From Cape York around the rocks of the Gulf of Carpentaria, the coast is of a low foreland type, formed of Desert Sandstone at first then of late Tertiary and Post Tertiary freshwater deposits, with an inner zone of marine Cretaceous rocks.

It is thought by some that the main submarine outlet of the Great Artesian Basin lies somewhere towards the southern shore of the Gulf of Carpentaria.

On the west side of the Gulf are numerous islands, formed of Permo-Carboniferous rock. A short distance inland from the mouth of the Roper River, the late Cainozoic sediments give place to Cambrian sandstones and limestones, the latter on the Daly River being largely formed of *Salterella hardmani*. These limestones are many thousands of feet thick and rest on an older volcanic series. From here around to Darwin, the coast is formed chiefly of Cretaceo-Tertiary and Permo-Carboniferous rocks, with an occasional low-lying outcrop of older Palæozoic or Pre-Cambrian rocks. Proofs of recent positive movement of the strand line are everywhere evident except between Arnhem Bay, the English Company's Islands, and Cape Arnhem, where there appears to have been recent negative movement. Elsewhere upraised Post Tertiary muds with echinoderms and crayfish and banks of dead coral are clear proofs of recent positive movement of the strand. One of the most beautiful parts of the whole Australian coast is that at the north-east extremity of Arnhem Land. Tectonic disturbances are present as major faults running N.E. and S.W. These are crossed by minor faults throwing to north-east. At Point Charles lighthouse, near Darwin, rolled specimens of *Ammonites* and *Scaphites* occur in great numbers.

At Port Darwin the coast is composed of whitish shales and sandstones containing numerous casts of *Belemnites*, and in places consisting almost entirely of radiolaria. These were originally deposited at a considerable depth, which suggests a positive movement of this part of the coast of that amount since Upper Cretaceous time, the epoch to which these rocks belong.

The remainder of the coast line is described in less detail in Chapter III., by T. Griffith Taylor. Readers are referred to that chapter for an account of the other physiographic features of the Commonwealth.

3. Palaeogeography and Present Relief.

Reference to the photograph of the relief model of Australia and Tasmania (Pls. I. and II.) shows the broad physical features of the Commonwealth, while the orographic map (Pl. IV.) gives the actual contour lines, and the tectonic map (Pl. III.) the chief trend lines. These maps, together with the sections (Plates VI. and VII.), show that Australia is essentially a vast peneplain This has been in part abandoned by the ocean, in part warped upward or downward in arches and compensating troughs, and this warping has been accompanied by heavy fractures. The latest of the true fold mountains of Australia dates back to Carboniferous time, for although in the Gympie region of Queensland the Permo-Carboniferous rocks are steeply tilted, they are never closely folded as the Carboniferous rocks often are. Great peneplanation took place in Permo-Carboniferous (Permian) time, followed by a considerable transgression of the sea in a wide belt sweeping inland on either side of Sydney, then swinging northwards through Queensland at least as far as Townsville. In Triassic and Jurassic time Tasmania with Bass Strait and Southern Victoria were covered by great lakes and swamps, in which the coal measures of that age were formed. Contemporaneously a vast lake stretched from at least as far east as Brisbane more or less continuously to Lake Eyre, a distance of nearly 1,000 miles. It is not known yet how far this great lake stretched in a meridional direction, but it must have been of the order of at least 500 miles. Gondwana Land was probably still in existence as far as can be judged from the Australian, Indian, New Zealand, South American, and Antarctic evidence. Now in late Jurassic or Post Jurassic time supervened those gigantic intrusions of diabase (dolerite) on a scale perhaps unprecedented in geological history. These intrusions took the form of sills which dominate the whole physical features of Tasmania, the Karroo, Antarctica and British Guiana. That these intrusions were connected with the sinking in of the Gondwana Land and consequent compensating warping up of the sea floor, and probably a further shallowing of the sea floor through submarine extrusions of the dolerite seems highly probable, and it may account for those world-wide transgressions of the oceans in Cretaceous time which Suess considers one of the most conclusive pieces of evidence in favour of the ocean surface at times undergoing an eustatic positive movement.

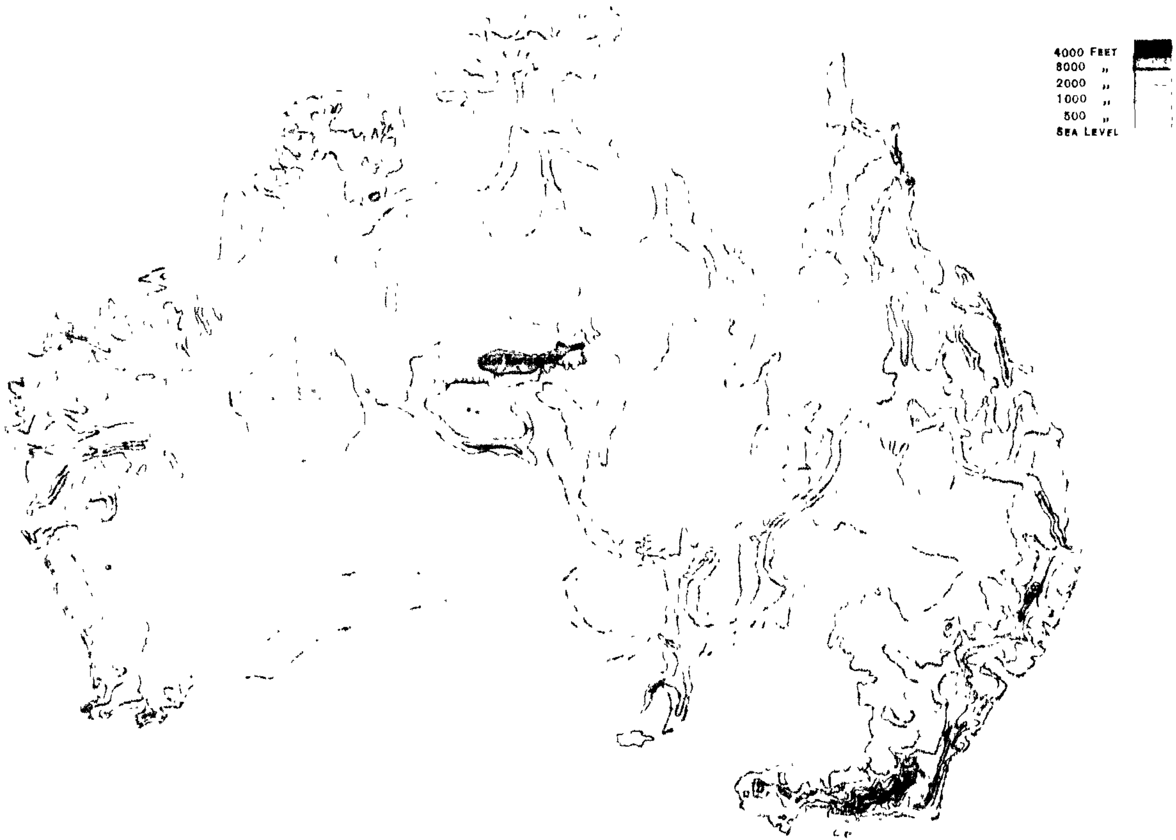
Australia was no exception to the general rule of transgressing epicontinental seas of vast size in Cretaceous time. During the older Cretaceous ("Rolling Downs") series, Australia was perhaps severed, so far as the portion of the continent which is still preserved is concerned, by a sea stretching from the Gulf of Carpentaria to the Great Australian Bight. The marine fauna of this sea is essentially that of a local Mediterranean. On the other hand, the Cretaceous rocks of the west coast of Western Australia have a cosmopolitan Cretaceous marine fauna closely resembling that of India.

Thus the old land barrier which united East Australia and India in Permo-Carboniferous (Permian) time does not seem to have been wholly broken down in early Cretaceous time.

In Upper Cretaceous time, marine conditions were largely replaced by lacustrine, the lake surfaces with small marine basins here and there covering about one-half of the whole area of Australia. During this period was deposited the so-called Desert Sandstone which at one time probably covered about three-quarters of the whole area of Queensland, one-third that of South Australia, and at least one-fifth of the total area of New South Wales.

In early Miocene time a considerable portion of southern and north-western Victoria, part of north-western Tasmania, the extreme south-west corner of New South Wales, a large area around St. Vincent and Spencer's Gulfs, and a still larger area at the head of the Great Australian Bight were submerged. It is important to note that the submergence crept inland as far as the surface of the peneplain at Lake Cowan, near Norseman, in Western Australia. Deposits of marine sponge spicules occur there superimposed on the peneplain. Some marine molluscan remains have also been found resting on the old peneplain on the shores of Lake Cowan, but unfortunately the geological age of these shells has not yet been determined. The date of the vast peneplain of Western Australia, Northern Territory, and probably that of East Australia as well, depends largely on the determination of the age of these fossils.

It has been argued that the Australian and Tasmanian peneplain survived without serious warping into Pliocene time. This provisional conclusion is based on the uniform character of the Pliocene flora as far as the few fragments of it preserved allow us to judge. This is thought to be due to the Australian land at this time over large areas being nearly reduced to sea level. That some warping of the peneplain had commenced probably as far back as the Oligocene, is proved by the fact that in Victoria the so-called "older basalts," of perhaps Eocene or Oligocene Age, are capped by the Lower Miocene marine beds, and there is evidence to show that Tasmania after being joined to Australia in early Tertiary times, was divided from the mainland by a strait in Middle Tertiary or early Pliocene time, then reunited or nearly reunited in late Pliocene or Pleistocene time, allowing the Tasmanian aborigines, ignorant of the building of sea-going canoes to migrate into Tasmania from the mainland. That the warping of the Australian and Tasmania peneplain was chiefly Post Miocene is proved by the locally folded and uplifted Lower Miocene beds in the Mount Lofty Ranges, near Adelaide. Also the latest great outburst of volcanic energy in all the States of the Commonwealth (except Northern Territory) took place in Post Miocene time. Moreover the glaciation of the Tasmanian highlands and those of south-east Australia, took place in late Pliocene or Pleistocene time, and these glaciations were almost certainly contemporaneous with accentuated crust warping, though it is not intended to suggest that there was necessarily a causal connexion between the two phenomena, though there possibly may have been. Next the existence of abundant remains of large herds of Pliocene or Pleistocene marsupials, some of elephantine proportions, in what are now low-lying arid regions, with the discovery of remains of the late Pliocene or Pleistocene crocodile *Pallimnarchus pollens*,

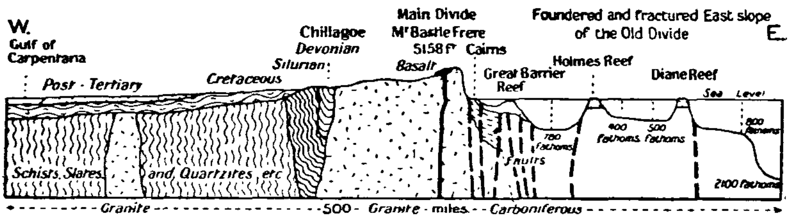

4000 Feet
8000 „
2000 „
1000 „
500 „
Sea Level

as far south as the valley of the Torrens, near Adelaide, demands a higher rainfall, warmer climate, and probably higher relief for the interior of Australia than it at present possesses. Then too, the canyons of the Upper Flinders, of the eastward-flowing New England rivers, like the Macleay, the Hastings, etc., and the canyons of the Blue Mountain rivers, the Shoalhaven River, etc., imply that no very great time has elapsed since the warping, otherwise the valley walls would be flared down and reduced to gentle slopes.

All over the highlands of Tasmania, as well as over the Kosciusko plateau, there is evidence of a succession of Glacial Epochs. These were probably synchronous with the recent maximum glaciation in Antarctica and in South America, possibly with the phases of the Great Ice Age in the Northern Hemisphere.

Amongst the newest of the tectonic movements has been the development of the great tensional faults, which have so strongly block faulted the Flinders Range (see fig. 1) and the main Eastern Divide, especially along the Barrier Reef area, where as in the neighbourhood of Cairns, the upper end of the Barron River is left hanging on the upthrow side of the fault block (fig. 3). The fault which bounds the Darling Ranges of Western Australia (fig. 2) on the west, probably is a development of very late Pleistocene or early Recent time.

FIG. 3.—Sections across Queensland.



4. Stratigraphical Features.

(a) The Geological Succession in the Commonwealth of Australia.

Group.	System.	Thickness in Feet.	Representative Formations.
POST-TERTIARY	*Recent* ..	..	1. River alluvium and sand dunes, with hard calcareous dune rock. Aboriginal kitchen middens. Laterites ("pindan" gravels and nodular ironstone). Nodular tufaceous limestone ("kunkar"). Salt deposits and muds of the "playas." Active crater of Mount Victory in Papua; recent craters of Mount Gambier (South Australia), Tower Hill, near Warrnambool (Victoria). The Great Barrier Reef of Queensland.
		1,000	= maximum thickness of dune rock.
			2. Raised beaches, mostly 15 feet above sea around Australian coast. In Papua recent coral rock extends up to 2,000 feet above sea-level. Submerged peat beds about 100 to 200 feet below sea to north of Sydney.
			3. *Helicidæ* sandstone of Bass Strait Islands, and *Helicidæ* limestone to west of Cloncurry, Queensland.

STRATIGRAPHICAL FEATURES—GEOLOGICAL SUCCESSION—*continued.*

Group.	System	Thickness in feet	Representative Formations
POST-TERTIARY—*continued.*	*Pleistocene*	..	4. Mammaliferous drift and old lake muds, with remains of *Diprotodon, Nototherium thylacoleo, Thylacinus, Sarcophilus, Sus papuensis* (in Queensland), together with *Pallimnarchus pollens, Megalania prisca, Genyornis, Canis dingo*, etc. In places these deposits may date back to late Pliocene.
			5. Glacial deposits of western Tasmania and of the Kosciusko plateau.
TERTIARY	*Pliocene* ..	300	6. Basalt sheets of the fissure eruptions in east and south-east Australia and Tasmania, Kangaroo Island (South Australia), and Bunbury (Western Australia). These range from Pliocene through Pleistocene to Recent. Newer "deep leads" of alluvial gold and tin in eastern Australia and Tasmania.
	Lower Pliocene or *Upper Miocene*	1,000 (?) 1,000	7. Older Marine Pliocene beds of Adelaide. Possibly Launceston Lake beds belong here. Port Moresby radiolarian cherts, etc.
		2,000	8. Belt of alkaline lavas and tuffs from Coleraine to Springsure, about 1,500 miles. Melilite and nepheline basalts of Tasmania.
		100 (?)	9. *Ostrea sturti* beds of the Lower Murray River. Lithothamnion limestone of Hallett's Cove, Adelaide.
	Miocene ..	80 to 1,000	10. *Cellepora gambierensis* limestones passing into chalk with flints, around the Bight. At Table Cape, Tasmania, the oldest Australian marsupial, *Wynyardia bassiana*, occurs in this formation. *Lepidocyclina* occurs in places.
		Several thousands of feet	Purari lignitic and oil-bearing series, Papua, with abundant *Lepidocyclina*
		200 to 1,500(?)	11. Older basalts and tuffs, and the older "deep leads" of Gippsland (Victoria), New South Wales, and southern Queensland. Much laterite and bauxite is associated with this series.
			12. Important brown coal series of Victoria, with fossil plants and lignites. At Morwell, in Gippsland, these lignites are 888 feet thick.
MESOZOIC ..	*Cretaceous*— Upper ..	100 to 300	13. Desert sandstone, mostly of freshwater origin, with thin seams of coal in places, passes downwards into radiolarian shales with belemnites. *Ichthyosaurus* occurs in the remarkable opal beds in this series. The sandstone is occasionally marine, with *Rhynchonella croydonensis.*
	Lower ..	2,000	14. Rolling downs formation, chiefly glauconitic sands and clays, with abundant foraminifera, *Maccoyella, Cytherea, Crioceras, Lamna, Belonostomus, Notochelone, Ichthyosaurus, Plesiosaurus, Aucella flindersensis*, Ammonite beds (Scaphites) of Darwin. The *Alveolina* limestones of New Guinea perhaps may be referred to this horizon. At Maryborough, Queensland, the Burrum coal seams are interstratified in the marine series.

STRATIGRAPHICAL FEATURES—GEOLOGICAL SUCCESSION—*continued.*

Group.	System.	Thickness in Feet	Representative Formations.
MESOZOIC—*continued.*	*Jurassic*—Upper ..	500 to 1,000	15. Diabase sills of Tasmania.
		1,000 to 3,000	16. Sandstones of the great artesian basin, with lignitic coal in places. At Leigh's Creek, south of Lake Eyre, a 47-ft. seam of brown coal in this series. Coal measures of Wonthaggi and Cape Otway Clarence Series, Clifton, Ipswich, Callide, and Broadsound. Quartz-trachyte tuffs of Brisbane. *Tæniopteris daintreei* is specially characteristic, and cycadaceous forms like *Otozamites*, *Pterophyllum*, and *Alethopteris* also abundant. *Unio eyrensis* numerous. Claw of dinosaur in Victoria, also fossil ceratodus. In Western Australia and Papua marine Jurassic rocks occur with abundant ammonites.
	Triassic ..	3,000	17. Productive coal measures of Tasmania. *Phyllotheca* present, with *Thinnfeldia*, *Alethopteris*, etc. Hawkesbury series of New South Wales, with abundant fossil fish, and large undescribed labyrinthodonts. Contains *Beyrichia*, abundant *Estheria*, *Tremanotus* (? *in situ*). Much red and green tuff at base of series.
PALÆOZOIC..	*Permo-Carboniferous (Permian)*	..	18. Acid granites of New England. Alkaline series of Port Cygnet, Tasmania, and of Kiama, New South Wales.
		1,500	19. Upper or Newcastle coal measures, with 35 to 40 feet workable coal. *Glossopteris* predominates over *Gangamopteris*. *Dadoxylon* abundant. The Upper Bowen coal measures of Queensland, and Collie coal-field, Western Australia, probably are on this horizon.
		2,200	Dempsey Series. Barren freshwater strata.
		500 to 1,800	Middle coal measures (Tomago or East Maitland), about 1,800 feet workable coal.
		6,400	Upper Marine Series, mudstones and sandstones, with abundant *Productus brachythærus*, *Crinoids*, "glendonite" pseudomorphs, occasional glacial erratics in shales, with abundant *Fenestellidæ*.
		100 to 300	Lower or Greta coal measures, with about 20 feet of workable coal. *Gangamopteris* predominates over *Glossopteris*. The Dawson coal measures probably belong here, in Queensland, and the Mersey coal measures of Tasmania.
		4,800	Lower Marine Series, with *Eurydesma cordatum* specially characteristic. Sodic basalts and andesite tuffs are interstratified. The series ends in glacial beds 300 feet thick. In Victoria there are the Bacchus Marsh beds, over 2,000 feet thick, with at least four beds of true tillite. At Wynyard, in Tasmania, and Hallett's Cove, near Adelaide, these tillites are very well developed. In Victoria and South Australia the tillites rest on beautifully striated pavements.

STRATIGRAPHICAL FEATURES—GEOLOGICAL SUCCESSION—*continued.*

Group.	System.	Thickness in Feet.	Representative Formations
PALÆOZOIC—*continued.*	* * * (Unconformity.)		The Gympie beds of Queensland are Lower Marine.
	Carboniferous.	..	20. Sphene-granites of New England.
			21. Blue-granites of New England.
		20,000	22. Star Series of Queensland, with *Lepidodendron australe*, *Aneimites*, and *Phillipsia*. The marine and freshwater beds in New South Wales, with *Phillipsia*, *Productus semireticulatus*, *Lepidodendron australe*, *L. volkmannianum*, *L. veltheimianum*, *Rhachopteris*, etc. A thick series of acid, to intermediate lavas and tuffs, occur in this system. In Victoria the Mansfield beds and the Grampians sandstones may be included here, together with the felsites and basalts of Mount Wellington, Victoria.
			23. Serpentine belt of New England, New South Wales.
	Devonian—Upper ..	10,000	24. *Spirifera disjuncta* quartzites of Mount Lambie, New South Wales, with *Lepidodendron australe*. The *Archæopteris* sandstones of Victoria may belong here.
	Middle..	9,000	Radiolarian cherts, reef limestones, and spilites of Tamworth, New South Wales. Burdekin series of Queensland, with reef limestone up to 7,000 feet thick, an ancestor of the Barrier Reef. Buchan and Bindi limestones of Victoria, with andesites. Devonian rocks of Kimberley, Western Australia.
	Lower..	14,000	Murrumbidgee series, New South Wales, with *Receptaculites* and bony-plated fish like *Asterolepis*, also a thick series of acid to intermediate lavas. In Victoria are the series of acid lavas and tuffs, the Snowy River porphyries. Dacites, quartz-porphyries, and granodiorites of this age occur in Victoria. Most of the granites of Tasmania are thought to be Devonian. Devonian rocks occur in Papua.
	Silurian ..	3,000 to 5,000	25. Shales, sandstones, limestones, contemporaneous tuffs. The type area is Yass, New South Wales. Hausmannia and Encrinurus, with the corals *Rhizophyllum* and *Mucophyllum* and *Pentamerus knightii* are characteristic. At the base of series is *Halysites* in great abundance. At Lilydale in Victoria, Chudleigh in Tasmania, Chillagoe in Queensland, limestones of this age are well developed. They are frequently associated with radiolarian cherts.
	* * * (Unconformity.)		
	Ordovician	9,000(?)	26. These rocks are either littoral, like the Tempe Downs beds, south of the Macdonnell Range, with *Asaphus* and *Endoceras* abundant, or are of the Victorian type, black shales, sandstones, graptolitic shales, with some sponge spicules, phosphatic slates, and cherts. They are also developed in New South Wales at Tallong, Mandurama, etc. The rich graptolite fauna is described later in this article.

STRATIGRAPHICAL FEATURES—GEOLOGICAL SUCCESSION—*continued.*

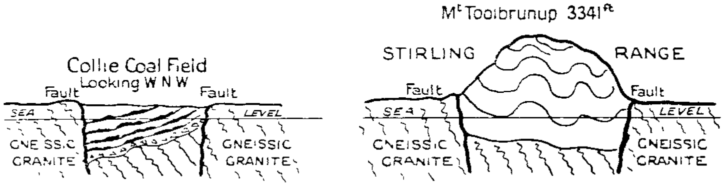
Group.	System.	Thickness in Feet	Representative Formations
PALÆOZOIC—*continued.*	*Cambro-Ordovician (?)*	..	27. These rocks consist of the diabases and tuffs, probably spilitic, of Heathcote and other areas in Victoria. Probably the porphyroid series with breccias, tuffs, etc., of western Tasmania also belong here.
	Cambrian	10,000(?)	28. This system is chiefly developed in South Australia and Northern Territory. In Northern Territory thick sandstones overlie massive *Archæocyathinæ* limestones, perhaps 7,000 feet in thickness, another forerunner of the Barrier Reef. Beneath the richly fossiliferous limestones (*Salterella* limestones of Northern Territory) is a vast thickness of basalts and basic tuffs. About half-way up in the series in South Australia are tillites up to about 1,000 feet in thickness.
	* * * (Great Unconformity.)		
PRE-CAMBRIAN	*Algonkian*	..	29. The Mosquito Series of the Pilbara gold-field, Western Australia, is a schistose group unconformably underlying the Cambrian(?) Nullagine Series. This in turn rests on an older series, the Warrawoona. Both may be considered Algonkian, as the rocks can be recognised as Sediments. At Kalgoorlie the conglomerates are Algonkian, as are those of Goat Island, Tasmania, with mica schists and garnet-zoizite-amphibolites; in the Mount Lofty and Flinders Ranges the rocks of the Houghton magma, so rich in titaniferous iron and diopside, and connected with radium deposits are also probably Algonkian. The Glenelg River schists and Mitta Mitta schists of Victoria may also be Algonkian, as well as most of the mica and quartz schists of Northern Territory.
	Archæan	..	30. Archæan rocks are widely spread in Western Australia in the Musgrave and Macdonnell Ranges, and at Port Lincoln, in South Australia, and between Camooweal and Borraloola, in Northern Territory. The Aguilar Range in Queensland, north of Brisbane, containing glaucophane schists may also be Archæan, as well as the main axis of British and German New Guinea.

(b) Pre-Cambrian System.

The rocks of this age, comprising both Algonkian and Archæan formations, are developed on a particularly grand scale in Western Australia and Central Australia, in fact, about one-third of the whole area of Australia, namely approximately 800,000 square miles, is occupied by this vast crystalline complex. Pre-Cambrian rocks are also developed in the Kimberley gold-field of Western Australia, as well as at Darwin, extending from the latter at intervals to Camooweal in Queensland. In New South Wales, they are represented by a belt of Garnetiferous mica-schist with amphibolites and

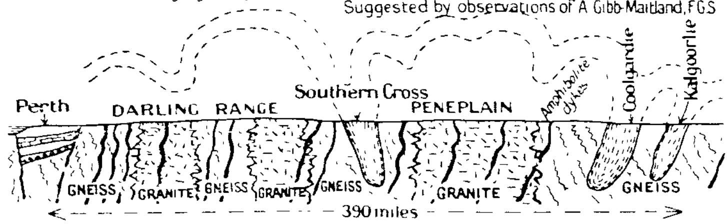
gneiss in the Barrier Ranges of the Broken Hill silver-field. They are represented by schists near the Cobar Copper Mines of New South Wales, and

FIG 4. DIAGRAMMATIC SECTIONS ACROSS COLLIE-STIRLING TROUGH
Vertical Scale 8000 feet to an inch



by a thick series of crystalline schists in a broad belt of country stretching S.S.E. from Wodonga and Tallangatta, through Omeo and Tongio West in North-east Victoria. Other areas occur in Victoria south of Mount Stavely and in the basin of the Glenelg River. In Tasmania, a well-marked belt of mica-schist and white saccharoidal quartzite, and a very interesting belt of zoisite-amphibolite, are ascribed to this group. With the exception of the last-mentioned rock, all the Pre-Cambrian rocks of Tasmania appear to have been of sedimentary origin, and should therefore be referred to the Algonkian system. In Western Australia, the group is divisible into two portions, or we may say that two groups are present: Firstly, an older form of gneisses and acidic schists with intrusive granite and pegmatite veins with numerous dykes of diorite, norite, dolerite, etc. Secondly, Algonkian rocks formed of coarse conglomerates together with, in places, altered volcanic tuffs and amygdaloidal dolerites, the latter evidently being of contemporaneous origin. The principal gold-fields of Western Australia, one of which alone (Kalgoorlie) has produced to date over £100,000,000 worth of gold, are situated in rocks, probably of this group, occupying deeply infolded basins, partly of Pre-Cambrian basic lavas and tuffs, in the older crystalline complex. As shown on the Section, Fig. 4, these Pre-Cambrian rocks have been intensely folded, the trend of the folds being nearly meridional, but on the whole having the form as shown on the Pl. III. of a very open inverted letter "S." One can distinguish at least four of these great gold-bearing basins from east to west in the following order:—Kanowna, Boulder and Kalgoorlie, Coolgardie, and Southern Cross. In the Pilbara district of Western Australia, there is a considerable development of minerals of the rare earths associated with veins of pegmatite traversing Pre-Cam-

FIG 5. Sketch roughly diagrammatic from Perth to Kalgoorlie.
Suggested by observations of A. Gibb Maitland, F.G.S.



brian rocks. For example, associated with tin-stone are found in this region tantalite in sufficient quantity to control the whole of the tantalum market

of the world. The mineral gadolinite, associated with well-crystallized monazite, and occasionally the rare radio-active mineral pilbarite, a lead-bearing uranium ore, are also met with within this area. At Mount Painter between the head of Spencer's Gulf and Lake Eyre, the Pre-Cambrian rocks comprise remarkably massive deposits with coarse mica-schists, containing an abundance of sapphire. These rocks are traversed by a huge lode containing radio-active minerals, such as monazite, torbenite, autunite, etc., together with a considerable amount of fluorspar. This lode has been traced along a continuous outcrop of over a mile, and in places is said to be over 20 yards in width—in places as much as 50 yards. At present the lode is only being prospected. At the Radium Hill, at Olary, on the railway line from Adelaide to Broken Hill, there is a considerable deposit of uranium-bearing titaniferous iron ore. At the surface outcrop this is stained lemon-yellow to orange by carnotite. The ore from this mine is at present being successfully treated at Woolwich, Sydney, and it is expected that it will soon be possible to produce not less than a gramme of radium bromide annually from this mine alone. In the MacDonnell Ranges, associated with the pegmatite dykes are large crystals of muscovite mica, from 1 foot up to 18 inches or more in diameter. Beryls in large crystals, but not of commercial value, occur in the same region. A remarkable rock in the Pre-Cambrian group is that known as the ribbon jasper. This rock, often many hundreds of yards in width, is typically a beautifully banded haematitic quartz rock. It can be traced for hundreds of miles along the gold-bearing belts of Western Australia. From its southern gold-fields, as far north as Kimberley gold-field, wherever reefs of quartz intersect it they are usually gold-bearing. Recent petrological research proves that this ribbon jasper is actually a mylonized quartz-dolerite, subsequently altered by silicification. It is singular that in other places as at Boulder, near Kalgoorlie, a similar mylonized quartz-dolerite has been converted into a graphite schist, probably as the result of long-continued emanations of methane. This gas is still being evolved from the gold telluride-bearing graphite-schists at the Great Boulder Proprietary Mine. At Bimbowrie, in South Australia, magnificent crystals of chiastolite, used for jewellery are abundantly developed in the Pre-Cambrian rocks. To the east of the Mount Lofty Ranges, in South Australia, there is a considerable development of andalusite-bearing schists, with which are associated schistose diopside-diorite. The latter rock is very rich in ilmenite, and black sands derived from this ilmenite are plentifully distributed throughout the basalt rocks of the succeeding Cambrian formation. Reference has already been made to the considerable development of Pre-Cambrian rocks in the neighbourhood of the Broken Hill silver mines. No attempt has as yet been made to form even a rough approximation of the thickness of the Pre-Cambrians, but it certainly must be very vast.

(c) Cambrian System.

Rocks of this age are developed on a grand scale in the northern part of Northern Territory, as well as between Lake Eyre and Kangaroo Island, to the south of Adelaide. They are also probably represented by the Nullagine series in the Pilbara region. At that gold-field, conglomerates perhaps of Cambrian age overlie quite uncomformably the older schists. These

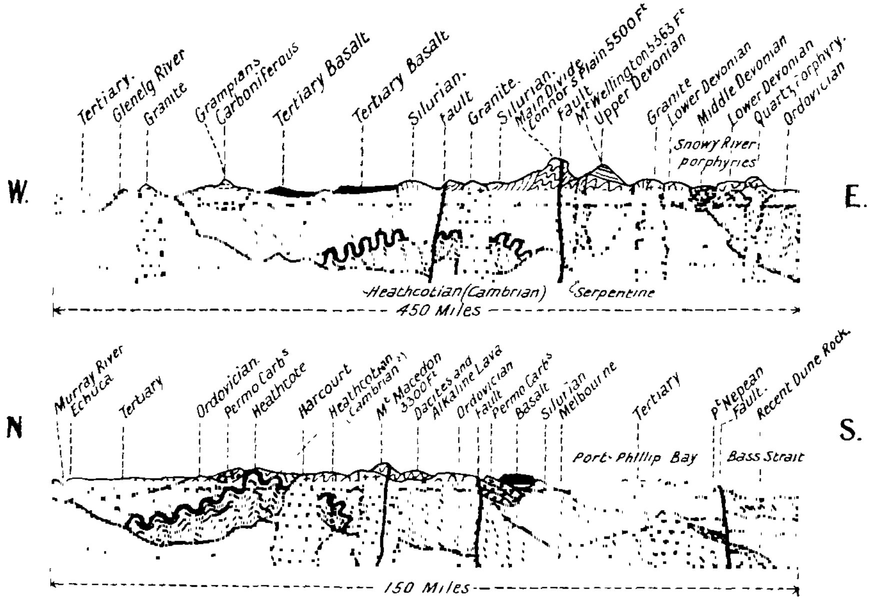
conglomerates contain gold and small diamonds, and are the oldest diamond-bearing horizon as yet proved within the Commonwealth. In the Northern Territory, in Arnhem Land, and in the Barclay Tableland, the Cambrian rocks there, largely formed of limestones, have proved invaluable as a source of supply of sub-artesian water. These limestones in the Northern Territory, at the Daly River, as well as at Mount Panton, in the Kimberley gold-field, are rich in the fossil pteropod—*Salterella hardmani*. Their thickness is certainly several thousands of feet, possibly 7,000 feet. In Arnhem Land and at Kimberley, these limestones overlie thick sheets of basic lavas, apparently contemporaneous in these Cambrian deposits. The two salient points of scientific interest about the system as developed in the Commonwealth are :—First, the development on a grand scale of glacial tillite. It has now been demonstrated that these glacial beds are in places fully 1,000 feet in thickness and extend from the Sturt Gorge, east of Adelaide, at least as far north as Pekina, to the north of Port Augusta, and may extend almost to the tropic of Capricorn, near Lake Eyre. The glacial beds of South Australia cross into New South Wales in the Barrier Ranges, about 20 miles north of Broken Hill. These glacial beds are met with about half-way up in the great thickness of Cambrian strata, and are many thousands of feet below the second feature about to be described, namely, the *Archaeocyathinae* limestones. These rocks are developed on a large scale at Yorke's Peninsula, to the west of Adelaide, as well as near Normanville and the Onkaparinga Valley, whence they extend at least as far north as the Blinnman and Ajax Mines, near Lake Eyre. They contain a rich and exquisitely preserved fossil marine fauna. It may be mentioned that small pieces of similar limestone were discovered by Sir Ernest Shackleton near Mount Darwin, about 360 miles from the South Pole.

The Heathcotian Series.

Shales and mudstones containing the trilolites *Dinesus* and *Notasaphus*, *Protospongia* and other sponge spicules, brachiopods and radiolaria occur about 3 miles north of Heathcote. These were originally referred to the Cambrian and later to the Ordovician. Recent evidence tends to reinforce their Cambrian age. Immediately underlying these beds to the east, come a mixed series of black cherts, cherty shales, and igneous rocks, principally basic lavas, described as diabases, tuffs, and agglomerates, with a few minor dioritic intrusions and a larger intrusive mass of micro-granite. To these rocks the term Heathcotian has been applied, and they have been described as underlying the Dinesus beds with a marked unconformity, and have been referred to the Pre-Ordovician and even to the Pre-Cambrian series. Others have pointed out that there is no evidence of unconformity between them and the overlying Ordovicians, but a gradual passage, and that therefore they cannot be older than Cambrian and may be Cambro-Ordovician in age. Similar rocks, with similar stratigraphical relations, and containing black cherts with *Protospongia* and radiolaria interbedded with diabases occur to the north-east of Lancefield. Probably the diabases and cherts of Mount Major, near Dookie; of Mount Stavely, and of the Hummocks, in the west of Victoria, are also referable to the Heathcotian series.

In Tasmania, Cambrian rocks of the nature of yellow rusty friable sandstones and quartzites occur at Caroline Creek, between Railton and Latrobe, as well as on the Humboldt Divide, and in the Florentine Valley. These rocks, which contain well preserved casts of *Dikellocephalus*, are considered to be of Upper Cambrian age.

FIG. 6.—Diagrammatic Sections across Victoria.



In Tasmania the Porphyroid Series of schistose quartz-porphyries, felsite tuffs and breccias, and spilitic basic rocks, of the Leven Gorge, Dundas, is presumably of Heathcotian, and therefore perhaps of Cambrian age.

(d) Ordovician System.

Two well-marked types, the one littoral, the other probably pelagic, are referred to this system. Shallow water strata of the former type have been described from the Tempe Downs Station and the Levi Range, to the south of the MacDonnell Ranges. These rocks show ripple marks and sun cracks, as well as cubical pseudomorphs in quartzite after rock-salt. Abundant well-preserved fossils, of which the commonest forms are *Orthis leviensis*, *Endoceras warburtoni*, *Asaphus illarensis*, are to be found in this neighbourhood in sandy calcareous shales. The other type of Ordovician rock, the dominant type in fact, consists of black carbonaceous shales and slates, with bands of fine-grained sandstones and quartzites and occasional conglomerates. They are best developed in Victoria where they are closely folded and strike generally in a N.N.W. direction. They are divided into a lower series, in which the black shales and slates on the whole predominate, and an upper series in which sandstones are more prominent, and containing

basal conglomerates as at Kerrie, east of Mount Macedon. The lower member has been divided by its graptolite zones into the following divisions from above downward:—

Darriwil series,
Castlemaine series,
Bendigo series.
Lancefield series.

The most productive gold-fields of Victoria, such as those of Bendigo, Ballarat, Daylesford, Maldon, Dunolly, Poseidon, and Steiglitz occur in Lower Ordovician rocks, near intrusions of granodiorite. It has been suggested that the quartz reefs are generally most productive where traversing black shales of the Bendigo series. The Lower Ordovician rocks have so far only been found in Victoria, and with the exception of the Mornington Peninsula, only to the west of a line running north from Melbourne and stretching to the western boundary of the State. The Upper Ordovician rocks are, on the whole, less closely folded than the lower series, are less auriferous, but have a generally similar N.N.W. strike, and occur only to the east of a line running north from Melbourne. Near Melbourne they occur at Diggers Rest, and further north at Kerrie, east of Mount Macedon. Inliers of Upper Ordovician rocks occur near the Woods Point gold-field, and also further east, surrounded by the broad belt of Silurian rocks, while very extensive areas in Eastern Victoria have yielded only Upper Ordovician graptolites.

Northwards from Victoria the Upper Ordovician rocks extend into New South Wales, sweeping in a broad belt to the east of Mount Kosciusko, between the Snowy River and Cooma. A belt of the same rock has been identified at Tallong, near Marulan, where it has been shown there is a great unconformity between this system and the overlying Silurian system. At Cadia, near Orange, there is a great belt of these rocks containing contemporaneous andesite lava, with large deposits of iron ore. Though extensive, these are not as large by any means as the great ironstone mountain deposits—the Iron Knob and the Iron Monarch—to the west of Port Augusta, from which the ore is to be obtained in the near future to supply the large steel works about to be erected at Newcastle. In Tasmania, strata of Ordovician age are represented at the Beaconsfield gold-field, near Launceston.

(e) Silurian System.

Strata of this age appear to be wholly restricted in the Commonwealth to the eastern portion of Australia and to Tasmania. In Tasmania they are well developed in the neighbourhood of the Mount Lyell Mine, where they contain the trilobite *Homalonotus*. The strata in Victoria are divided into the Upper or Yeringian and the Lower or Melbournian series. At Lilydale, in Victoria, there is a well preserved marine fauna in the limestones of that locality. These strata are not so strongly folded as those of the Ordovician System. Perhaps the richest fossil-bearing locality for the Silurians is to be found in the Yass district of New South Wales. The rocks there consist of contemporaneous dacite tuffs with sandy shales, olive coloured to yellowish brown shales and numerous beds of limestone. The limestones are built up of a rich coral fauna. In fact, they are obviously old fringing coral reefs. One of the most common and characteristic corals is the mushroom shaped form,

Mucophyllum. *Pentamerus* is very plentiful near the limestones in the middle system. *Halysites* is very common and characteristic in the lower limestones of the system, being so abundant at Spring Creek, near Orange, and at Molong, as to constitute by itself coral reefs. In the upper strata the trilobites *Hausmannia* and *Encrinurus* occur plentifully. The famous Jenolan caves of New South Wales have been hollowed out of limestones rich in *Pentamerus*. These are capped by massive black cherts, chiefly composed of radiolaria. At the limestone reefs at Wellington, New South Wales, beautifully preserved siliceous sponges allied to *Astylospongia* may be collected, weathered out of the surface of the limestone. Silurian rocks so far have been identified in Queensland only in the neighbourhood of Chillagoe, where limestones containing *Halysites* are developed. At the same time it is considered probable that a belt of Silurian extends through Queensland, from the south of Boulia to the extreme north-west, and from 20 miles east of Cloncurry to the western boundary of the State. The Stirling Range, in the south-western portion of Western Australia, has been doubtfully referred to this period.

(f) Devonian System.

This is the oldest system in the Commonwealth in which definite fossil plants have been discovered, and such give evidence of a great extension of the land surface of Australia in an easterly direction since the close of Pre-Cambrian time. They occur at intervals all the way round from Kimberley to Cloncurry, the Burdekin basin, the Tamworth area, the region west of the Blue Mountains between Mudgee and Bowenfels, as well as in a parallel strip near Wellington, Spring Creek, near Orange, and Canowindra. They are also represented at the Yalwal gold-field, to the south of the Illawarra District, as well as on a large scale at Burrinjuck, and also in the Pambula regions. In addition, outlying patches of Devonian rock occur at Cobar, Oxley's Tableland, Gundabooka Mountain, and White Cliffs, beyond Wellington. Southwards they can be traced into Victoria, as the Snowy River porphyries and the Buchan and Bindi limestones and the Tabberabbera shales. No undoubted Devonian rocks have as yet been proved in Tasmania, in South Australia, or in Western Australia south of Kimberley. The system is divisible into three series. The lower is often chiefly volcanic, consisting of banded rhyolites and tuffs. These are associated with reddish-purple to chocolate coloured shales. In places the volcanic rocks become basic. In the neighbourhood of Burrinjuck and higher up the Murrumbidgee River, near Taemas, there is a splendid development of folded Lower Devonian limestones. A conspicuous and characteristic large fossil in these rocks is the form *Receptaculites*. Remains of large bony-plated fish, such as *Coccosteus* and *Asterolepis*, have been found in these limestones. In Victoria, the Buchan and Bindi limestones occupy eroded hollows in the surface of the Snowy River porphyries. The Grampian Range of white, grey, red, and purple sandstones and conglomerates perhaps belongs to the Upper Devonian beds. The conglomerates, sandstones, and shales of Mansfield, Victoria, are perhaps of Upper Devonian age. In New South Wales, Middle Devonian rocks are well represented in the Tamworth region by massive coralline limestone, in which the curious

type *Sanidophyllum* is a dominant form. Associated with the limestones is a vast thickness, about 9,000 feet, of tufaceous cherty shales, with concretions of radiolarian limestones. In some of these the radiolaria are exquisitely preserved. Interbedded in the shales are numerous casts of *Lepidodendron australe*. In Queensland the chief development of Devonian rocks is in the Burdekin basin. There they consist of very massive conglomerates at the base, passing upwards into coral reef limestones of vast thickness. On the Manning River they are no less than 7,000 feet thick. The most characteristic fossils are *Pachypora meridionalis* and *Stromatoporella*. With these are associated fossil plants such as *Dicranophyllum*, as well as a remarkable undescribed form. Upper Devonian rocks are mostly represented by reddish to grey quartzites, sandstones, and red shales. They are typically developed at Mount Lambie, Mount Walker, and Spring Creek, near Orange, New South Wales. These strata are very rich in *Spirifera disjuncta* and *Rhynchonella pleurodon*. Lastly, at Kimberley, in Western Australia, there is a belt of marine Devonian rocks containing a fauna which suggests that it may be of Middle Devonian age.

(g) Carboniferous System.

With perhaps the exception of a small belt of rocks at Kimberley, which is rumoured to contain *Lepidodendron*, and the Grampians sandstones in Western Victoria, which have recently yielded forms of *Lingula* and fish remains similar to those of the Mansfield rocks, no rocks of this age are known to be developed in Australia, to the west of a line joining Cape York with Melbourne. No trace of *Lepidodendron* has as yet been found in Tasmania. The genus is widely represented in Queensland, where much of the folded highlands of the north-eastern coast ranges are built up of these rocks.

The latest folding to which the earth's crust in Australia has been subjected belongs to late Carboniferous time. So far no marked unconformity has been traced between the Devonian and Carboniferous rocks. Rocks of true Carboniferous age in the Commonwealth are characterized by the presence in their lower strata of *Lepidodendron volkmannianum*, *L. veltheimianum* and *L. dichotomum*, and in their upper portion by several species of *Rhachopteris* and *Aneimites*. So far no single example of a *Lepidodendron* has been found anywhere in the Commonwealth in rocks of so-called Permo-Carboniferous age. A marine fauna is associated with this system particularly in its lower and middle portions. An important form to distinguish the Carboniferous rocks from the Devonian on the one hand, and the Permo-Carboniferous on the other, is *Phillipsia*. So far no trace of trilobites has ever been observed in any of the true Permo-Carboniferous rocks. *Michelinia* and *Lithostrotion* found in New England are essentially Carboniferous forms which never ascend into the Permo-Carboniferous systems. Less reliance can be placed on the brachiopods, many of which, such as *Productus semireticulatus*, *Orthis*, and *Streptorhynchus*, &c., ascend into the Permo-Carboniferous system.

The upper series of the Carboniferous system is characterized by a vast thickness of lavas and tuffs, mostly acidic such as rhyolites and ceratophyres associated with hypersthene andesites and hornblende andesites and magnetite-sandstones. Intrusions of granites and quartz-porphyries occur on a

grand scale in this system, and it may be assumed that the rhyolites and other acid lavas are the volcanic representatives of the granite batholiths. As regards local development, Carboniferous strata formed of reddish shales and sandstones are most typically developed in Victoria, near Mansfield. They there contain *Lepidodendron australe* with an abundance of fossil fish such as *Gyracanthides murrayi*, *Acanthodes australis*, *Eupleurogmus cresswelli*, *Strepsodus decipiens*, *Ctenodus breviceps*, *Elonichthys sweeti*, *E. gibbus*. It may be mentioned that it has been proposed to place these beds in the Upper Devonian, the occurrence of *Lepidodendron australe*, the the most characteristic of our Devonian plants, suggesting this possibility; but at present the Victorian geologists prefer to class these strata as Lower Carboniferous. The occurrence of *Lepidodendron australe* in beds of undoubted Carboniferous age in the Star series of Queensland seems to justify this classification.

In New South Wales the Carboniferous system is about 20,000 feet in thickness, and extends in a wide folded belt from Port Stephens northwards into New England, reaching the Queensland border near the Horton River.

(h) Permo-Carboniferous (Permian) System.

Of all the sedimentary formations developed in the Commonwealth this system is perhaps the most interesting by reason, in the first place, of the wonderful evidence of past ice action; in the second place, on account of the remarkable development of the *Glossopteris* and *Gangamopteris* flora which replaced everywhere within the Commonwealth the *Lepidodendron* flora of the preceding system; and, in the third place, this system is specially interesting on account of its marine fauna, which belongs to two sharply differentiated types—the western, allied to the Permo-Carboniferous fauna of India; and the eastern, a distinct fauna unlike, in many respects, any developed in other parts of the world. It is also interesting on account of the fact that probably nowhere else in the world are the strata of the Permo-Carboniferous system of such thickness, or so rich in diversified forms of animal life. It is not proposed to discuss the Palæontology of this system here, as Mr. W. S. Dun has given a summary of it at the end of this article, and details are given in the handbooks for the various States.

In regard to the upward passage from the Carboniferous strata into the Permo-Carboniferous, it may be said that, while there is little evidence of unconformity in some places, in others the unconformity is fairly strongly marked; as, for example, near Lochinvar in the Hunter Valley of New South Wales. At the same time, the unconformity is not nearly as strong as that developed in the British Isles, between the dolomitic breccias of the Permian system, and the Carboniferous rocks.

It has already been stated that the Carboniferous strata in the Commonwealth are mostly disposed in fairly close folds. On the other hand, the strata in the Permo-Carboniferous system are either perfectly horizontal or disposed in broad open troughs and arches. Only in the case of the strata at Drake and Underclift in New England and of the Ashford areas in New South Wales, and the Gympie area in Queensland, are the strata of this system highly disturbed near granitic intrusions.

In regard to the term "Permo-Carboniferous," in view of the present state of our knowledge it is somewhat of a misnomer. The term was applied, in the first case, by Messrs. R. L. Jack and R. Etheridge, jun., to certain strata in Queensland, which undoubtedly did unite between themselves forms of life, chiefly marine, partly characteristic of the Carboniferous, partly of the Permian. It is now known that in Queensland these rocks can be sharply divided into two groups, viz.: an older group, in which *Lepidodendron* and *Phillipsia* are present; and a younger group, in which neither of the above fossils ever occur, but which contains a marine fauna distinctly comparable with that of the Hunter River region of New South Wales. In spite of the fact that some of the brachiopods of this Permo-Carboniferous system show affinities with those of the Carboniferous, it appears to the writer that there is no longer need for the retention of the term Permo-Carboniferous, but that the strata of this system should be considered to be Permian for the following reasons:—

(1) At the very base of the system is a thick and widely developed series of beds of glacial origin, which can be certainly correlated with the Dwyka beds of South Africa in the Karroo system, also with the Talchir beds in India, as well as with the glacial strata known as the Orleans Conglomerate of the Santa Catharina system of South Brazil and of the Argentine.

Now, in South Africa the marine reptile *Mesosaurus* is found in strata conformably overlying the gracial beds of the Dwyka series, so that, presumably, this reptile was more or less contemporaneous with the Dwyka ice age. Similarly, in Southern Brazil, we meet with remains of *Mesosaurus* in strata conformably overlying the Orleans conglomerate. Still further north we encounter the well-marked Permian fossil *Schizodus*, and other marine forms, in shaly strata apparently on the same geological horizon as that containing the above reptile.

If, therefore, *Mesosaurus*, a powerful marine swimmer and therefore a rapid migrator, is really Permian, then the Orleans conglomerate and the Dwyka conglomerate are also of approximately this age.

(2) We find that in Russia, in the neighbourhood of Moscow, a flora rich in *Glossopteris* and *Gangamopteris*, as shown by Amalitzky, overlies sandstones, marls, &c., which at Brasnoborsk contain *Bakewellia ceratophaga*, Schl., and *Schizodus rossicus*, Vern. All the above strata in Northern Dwina are considered by Kohen to be referable to the Zechstein.

But while the term Permian might probably be substituted with advantage for the term Permo-Carboniferous in Eastern Australia, it is doubtful whether it is equally applicable to the so-called Carboniferous rocks of Western Australia, in the Kimberley District In other parts of Western Australia, where so-called Permo-Carboniferous rocks are developed, as at the Gascoyne, Wooramel, and Minilya Rivers, a well-marked glacial horizon the "Lyons conglomerate," underlies the bulk of the so-called Carboniferous strata. There is now little doubt that this glacial horizon is identical with that of Bacchus Marsh, in Victoria, Hallett's Cove, in South Australia, Wynyard, in Tasmania, and Lochinvar, and Kempsey in New South Wales. All the strata above this glacial horizon might fairly be termed Permo-Carboniferous

at any rate, if not Permian. In the Kimberley District of Western Australia, the glacial horizon has not been identified definitely, and perhaps does not exist there, but the fossils are essentially similar to those above the glacial horizon of the Lyons conglomerate, and may therefore provisionally be classed as Permo-Carboniferous and even Permian.

While therefore considering that there is much to justify the term "Permian" being substituted for that of "Permo-Carboniferous," the writer proposes to retain temporarily for the purposes of this article the old term "Permo-Carboniferous," chiefly because it has been so widely used, and generally accepted.

As regards geographical distribution, rocks of this system are very widely spread throughout the Commonwealth. In Tasmania about one-half of the island, which is rather bigger than Ceylon but smaller than Ireland, is covered with rocks of this age. They commence with an important series of glacial beds, having a total thickness of about 800 feet. Splendid sections of this can be seen between tide marks on the beach to the east of Wynyard. Several striated pavements occur in the tillite, which show that the ice moved from about S.S.W. to N.N.E. An interesting fact which has lately come to light is that there are at least three, perhaps four distinct tillite horizons, and these are separated from one another by strata perhaps representing inter-glacial epochs. Each tillite horizon can be correlated certainly with those of Victoria, and almost certainly with those of South Africa, and these are succeeded by marine strata belonging to the Lower Marine series, over 600 feet thick at this locality. This series is followed by one of the most important coal-bearing horizons in Australia, viz., the Greta series. In Tasmania, however, the series is represented by only a few seams of coal, from 20 inches up to 3½ feet in thickness. In places this coal passes into kerosene shale, formed largely of the problematical plant considered to be an alga, *Reinschia australis*. Above the Greta series is a considerable development in Tasmania of rocks of the Upper Marine series. In Tasmania the great series of freshwater coal measures developed in New South Wales and Queensland above the Upper Marine series are wanting, and in Tasmaina rocks of Trias-Jura or Jurassic age rest conformably on the topmost Marine beds of the Permo-Carboniferous system.

In Victoria there is a wonderful development of glacial beds of the nature of tillites associated with contemporaneous conglomerates and ripple-marked sandstones, together with fine clay shales. The whole series passes upwards into sandstones containing *Gangamopteris*, and is over 2,000 feet in thickness. Hitherto no marine strata nor coal seams have been discovered in Victoria in this system. These glacial beds lie on a surface of low relief, though in places, as at the Werribee Gorge, the tillite fills an old U-shaped valley, perhaps an overdeepened valley. The rocks on which the tillite rests, mostly of Ordovician age, with Post Ordovician granites are very strongly striated and grooved by ice coming from a southerly direction. The sandstone beds between the tillites show strong evidence in places of contemporaneous contortion. As the matrix of the tillite varies with that of the subjacent rock, there can be no doubt that the tillite was formed by an immense sheet of land ice, the main mass of which lay to the south. These glacial deposits can be traced at intervals across Victoria, northwards by

way of Heathcote to Beechworth, close to the southern border of New South Wales, and fine striated pavements can be seen at Derrinal, near Heathcote, together with erratics up to 30 tons in weight. Westwards they extend under the level plains of Tertiary rock, having been proved to underlie Nhill. To the south of Adelaide, between that city and the mouth of the Murray River, there are magnificent cliff sections showing the junction of these old glacial beds with the Lower Cambrian strata. Beautiful striated pavements are to be seen in the Inman Valley, Hallett's Cove, etc., which prove that the ice came from a south by east direction. The glacial beds are there, with their associated conglomerates, sandstones, and shales, fully 900 feet in thickness, but so far in South Australia, as in Victoria, no productive coal of this age nor marine fossils have as yet been found. In fact there are considerable patches there of Permo-Carboniferous glacial landscape re-discovered by modern denudation. Still further west, in the south-west corner of Western Australia, there is a small basin, preserved in a deep trough fault, known as the Collie coal-field. This coal-field contains the fossil plant *Gangamopteris*, associated with numerous seams of coal up to over 10 feet in thickness, but the strata are so very porous, that when shafts, bores or tunnels are made in these measures they become veritable artesian wells. The coal itself, contrary to usual experience in strata of this age, is distinctly hydrous. Northwards from Perth the Irwin River region has preserved a small patch of glacial beds immediately underlying richly fossiliferous marine strata including limestones, and conformably overlying brown clay shales. Two seams of coal conformably overlie the marine strata, the main seam 5 feet thick and though not so proved by fossils, presumably of Permo-Carboniferous age. Still further north in Western Australia, the glacial conglomerate has been traced from near the Carnarvon bore at the mouth of the Gascoyne River to the Wooramel River, and almost up to the latitude of North-west Cape. Thus in Western Australia these Permo-Carboniferous glacial beds actually touch the region of the tropics. As evidenced by the nature of the contained boulders, when compared with their nearest parent rocks, it is clear that the ice sheets, which produced this glaciation, moved, on the whole, from the inland plateau westwards or northwards, probably in a north-westerly direction, inasmuch as the glacial boulders become progressively larger the further south they are traced. These glacial beds are known as the "Lyons conglomerate." So far no striated floor has been discovered beneath them. In the Kimberley district of Western Australia there is a considerable development of marine Permo-Carboniferous calcareous sandstones and limestones, and it has been proved that these Carboniferous strata from the Gascoyne River to the Kimberley District contain invaluable supplies of artesian water, though strange to say they are quite wanting in productive coal seams as far as they have yet been tested. Strata of this age extend further east around the Australian coast to the Victoria River. The marine strata at the Victoria River are associated with fresh-water shales containing *Glossopteris*. This *Glossopteris* underlies strata which contains *Orthotetes* and *Aulosteges*. This formation has been traced across into Arnhem Land (to the north-east of Darwin), and to the islands of the north-east extremity of Arnhem Land. Groote Island is thought to belong to this system. A remarkable feature is that from the Gulf of Carpentaria

around to the Irwin River region the whole assemblage of marine Permo-Carboniferous fossils is distinctly of Indian type. S.S.E. of Cape York is a deep indent in the coast line, marking a prolongation of the trough valley in which lies the Permo-Carboniferous coal-field of the Little River. As the result of heavy downthrows, the strata have been forced into rather sharp zigzag folds, a rare structure in rocks of this age in Australia. Near Townsville is a small development of Permo-Carboniferous strata, which there underlie the coastal plain, and extend out to sea beneath the coral reefs of the Great Barrier. Next we reach the classical coal-field of the Bowen River. There evidence of glacial action, in the form probably of floating ice, is to be found in the shape of numerous small boulders of granite and other rocks foreign to the district embedded in the clay shales of the Permo-Carboniferous system, but nothing approaching a true tillite has ever been observed in this area. Next, on the south, come the extensive and thick coal seams of the Dawson River basin. The thickest seam known in Australia in rocks of this system occurs near Comet, where it is 80 feet thick. Anthracite of excellent quality occurs in a seam 11 feet thick on the Dawson River, about 30 miles south of Duaringa, but unfortunately the coal-field in that area is much broken up by faults. The Permo-Carboniferous system in this important coal-field can be divided up into the following groups arranged in ascending order :—

Lower Bowen	At the base, marine beds such as those of Gympie, with boulders presumably transported by ice. Next, Lower Marine strata followed by a volcanic series. Above this follow sedimentary rocks, with the 11-ft. seam of anthracite already described. This is followed by the marine shell beds of Oakey Creek and St. Marys, in turn capped by the *Glossopteris* beds of Oakey Creek and St. Marys.

All these strata are grouped together as Lower Bowen. There follows a slight unconformity and above it are developed the marine shell beds of Claremont and Capella. Above these again, and slightly unconformable to them, are the Tolmie's coal measures. The latter are capped by the old auriferous conglomerates of Claremont. The whole of this last series is grouped together as Upper Bowen. No estimate has, as yet, been formed of the available quantity of Permo-Carboniferous coal in Queensland, but it must be very vast, perhaps, approximating to the 100,000,000,000 of tons roughly estimated to be present in the form of exploitable coal in New South Wales.

South-east of the Dawson field the Permo-Carboniferous strata are represented by the basal marine beds of the Gympie gold-field. It has been the experience there that wherever the quartz reefs, which traverse these strata, come in contact with the occasionally intercalated beds of black carbonaceous shale, they are payably gold-bearing. The Dawson coal-field, traced in a southerly direction, reaches the borders of New South Wales, near Bonshaw and Ashford. At the latter locality a fine seam of anthracite coal, 27 feet in thickness, is to be seen in the left bank of the Severn River. As *Gangamopteris* is the only fossil known to occur in association with this seam, it may provisionally be considered to be of Greta age. This field occupies a narrow

fault trough. About 100 miles east of this spot at Undercliff, there are beds of graphite associated with intrusive acid granites. These graphite beds are considered to represent intensely metamorphosed coal seams of Permo-Carboniferous age. These graphitic strata are to be connected with marine beds of undoubted Permo-Carboniferous origin as at the gold-field of Drake, where contemporaneous acid and basic lavas are inter-stratified with the lower beds.

South from Ashford, the region of Gunnedah is reached, from which the principal coal-field of New South Wales extends without a break for fully 300 miles, as far south as the head of the Clyde River, near Ulladulla. The type district in this field is that of Maitland, in the Hunter Valley. The system is there ushered in, at Lochinvar, by reddish-brown clays with numerous glacial boulders, but hardly deserving of the name of a true tillite. These beds are about 300 feet in thickness. They are followed by nearly 4,800 feet of strata, mostly of marine origin, with an exceptionally rich Permo-Carboniferous fauna. The fossil *Eurydesma cordata* is especially characteristic of these Lower Marine rocks. Its frequent association with coarse conglomerates shows that it was littoral in habit. The fine state of preservation of the marine shells at the classic spot—Harper's Hill—is due to the fact that they were suddenly overwhelmed in showers of contemporaneous volcanic ash, which has effectually preserved them to the present day. Large *Aviculopectens* and vast numbers of polyzoa, belonging to the family of the *Fenestellidae* also abound, and may possibly have some relation to cold water conditions, just as at the present time one sees the icy seas of the Antarctic swarming in polyzoa and pectens. The Greta coal measures, from 100 to 300 feet thick, which conformably overlie the Lower Marine series, are not relatively rich in fossil plants. It is significant that in these measures *Gangamopteris* predominates over *Glossopteris*, whereas in the higher coal measures of this system the reverse is the case. It should here be mentioned that the *Gangamopteris* has been found as low down as 2,000 feet below the Greta coal measures in the middle of the Lower Marine series. The Greta coal measures usually contain about 20 feet of workable coal, and, exceptionally as much as 40 feet. The Upper Marine strata, which follow the Greta, attain their maximum thickness yet proved in the Hunter River region, viz., 5,000 to 6,400 feet. About half-way up in the series erratics, certainly of glacial origin, are very numerous in places, occurring usually in groups. Many of these blocks of rock are one to two tons in weight, and appear to have been derived from the region of Mount Lambie, near Rydal or Bathurst, about 200 miles to the south-west. It is significant, probably, of glacial conditions, that we find an almost total absence of reef-forming corals in the Permo-Carboniferous strata. Such corals as do occur are slender types like *Zaphrentis* and *Trachypora*. Near the top of the Upper Marine series, as well as on certain horizons lower down, are remarkably large pseudomorphs known as glendonite. These crystals attain a length of from 2 ins. to 1 foot. They are best seen on the beach between tide marks at Huskisson, Jervis Bay, about 100 miles southerly from Sydney. The shore here presents the appearance of a medieval battlefield, strewn with spear heads and caltrops. They are pseudomorphs after the double sulphate of sodium and calcium, glauberite. As deposits of sodium sulphate are very common and

characteristic in Antarctica, these glendonites may have some climatological significance. They have also been found in Tasmania, close to the horizon of the oil shale known as Tasmanite, in part of the Mersey coal-basin. Above the Upper Marine follow the strata of the Middle Coal measures, known as the East Maitland or Tomago measures. These are from 500 to 1,800 feet thick and contain in the aggregate about 40 feet of coal, which, being more friable than that of the Greta, is not so suitable for export, though useful for household, gas, and blacksmith purposes. A total thickness of about 18 feet of coal is worked. In parts of the Hunter River coal-field, there follows a considerable thickness, in places about 2,000 feet thick, of fresh water strata, with abundant plant remains, but devoid of any coal seams of workable thickness. These beds belong to the Dempsey series. Next, above the Dempsey, comes the Newcastle series, 12,000 to 14,000 feet in thickness, with about 120 feet of coal. The thickness of the seams varies from 1 foot up to about 27 feet. The aggregate thickness of workable coal in this series is from 35 to 40 feet. On the shores of Lake Macquarie, at Awaba, as well as at the southern entrance to Lake Macquarie, known as Reid's Mistake, are fossil forests of coniferous trees. At the latter locality it can be seen that the trees sprang directly from the upper portion of a coal seam being actually in position of growth. The lower parts of the stem are of carbon, but upwards they pass into chalcedony, where they have been buried under showers of very fine volcanic tuff. The tuff has evidently broken down branches of the trees, and resin has exuded from the fractures, and is preserved now in the form of black drops in the tuff, the latter being converted into chert. Some of these coniferous trees can be seen to be over 100 feet in length.

It may be said that, on the whole, the evidence points to the coal seams in the whole of the Permo-Carboniferous system, having formed, for the most part, at the spot where seams are now found. For example, in the under clay, only thin rootlets have been observed. In the clay bands higher up, in the seam numerous specimens of *Vertebraria* can be frequently seen in position of growth. It is only in the actual roofs of the seams that forest trees like the conifer *Dadoxylon* have been proved to exist. In places, but rarely, remains of fossil fish, and of labyrinthodonts have been discovered in the coal measures, from those of Greta age up to those of Newcastle age. For example, a small labryrinthodont has been recorded from the Mersey coal measures (Greta horizon) near Railton, and another was found in the kerosene shale at Airlie, in the western coal-field of New South Wales. *Palaeoniscus* has been obtained from the marine (probably lower marine) Permo-carboniferous rocks of Tasmania, and *Urosthenes* from the Newcastle coal measures of New South Wales. The total amount of exploitable coal in seams not less than 3 feet thick and not more than 4,000 feet in depth in these measures in New South Wales, is estimated to be roughly about 100 000,000,000 tons.

Summary—(1) In regard to Palæogeography the ice which glaciated Tasmania, Victoria and South Australia, came from the south from a land probably a local extension southwards into the Southern Ocean, of the Australian continent. The glaciation of Cambrian time, in Australia, came from the same quarter. In Western Australia, the glaciation is thought to

have come from the south-east, from local highlands. near the southern end of Western Australia. In Eastern Australia, the region affected by the glaciation was a landscape apparently of low relief. but we know nothing of the height of the gathering ground of the ice sheets on the now sunken part of the continent, where the eastern end of Jeffrey's Deep shows a depth of 3,000 fathoms. Possibly the great bank recently discovered which lies about 200 miles south of Tasmania, and which rises from great ocean depths to within 500 to 600 fathoms of the surface formed part of a high south-eastern margin to Australia, extending from this bank to Kangaroo Island in Permo-Carboniferous time. This was no doubt in part a gathering ground for the inland ice. In New South Wales, there seem to have been local alpine glaciers. In south-western Western Australia. there seems to have been a local ice sheet.

(2) There were at least three interglacial phases in Australia, probably to be correlated with those of Africa. (3) The fauna especially in disappearance of Carboniferous reef-forming corals suggests general refrigeration of the seas, while the flora of the coal seams is not inconsistent with that of a climate like that of Macquarie Island. (4) Snow line touched sea level probably near 40 degrees S. latitude in Permo-Carboniferous time, and glaciers came down to sea level at about 34 degrees S. latitude. (5) This may demand a fall of temperature as compared with the present of about 10 degrees C.

(i) Trias System.

Rocks of this age are at present known to be developed chiefly in the Sydney and Blue Mountain areas of New South Wales. In Tasmania, however, the Knocklofty Series, variegated sandstones, 1,000 feet thick, which, in the neighbourhood of Hobart, overlie the Permo-Carboniferous strata, have been doubtfully referred to some part of Triassic time. They contain remains of *Acrolepis hamiltoni* and *A. tasmanicus*, and bones of, probably, a labyrinthodont. The occurrence in the sandstones of *Vertebraria indica*, Royle, suggests affinities with the Permo-Carboniferous system. The Ida Bay Series containing *Zeugophyllites* and *Pecopteris lunensis* are perhaps Triassic. In regard to the Fingal Series in the Tasmanian coal-measures, as some doubt exists as to whether they belong to the top of the Trias. or to the base of the Jurassic, they will be described later.

The Triassic strata of New South Wales extend along the coast from the Cambewarra Ranges in the south to Lake Macquarie, near Newcastle, in the north, thence they stretch inland to beyond Gunnedah, on the north-west, and westwards to a little beyond Lithgow.

The rocks in this area have been divided, chiefly lithologically, into three stages which, in descending order, are as follows :—

Wiannamatta shales.—Thickness about 600 feet.

Hawkesbury sandstone.—Thickness about 300 to 1,000 feet.

Narrabeen beds.—Thickness about 200 to 2,000 feet.

The strata of the Narrabeen Stage are largely tufaceous, but the true tuffs do not constitute more than about one-tenth part of the whole thickness of the Stage. In their lower portion they are mostly grey to greenish-grey sandstones, with greenish conglomerates and grey-green and reddish to chocolate-coloured shales. Five hundred feet above the Bulli coal seam (the top of

the Permo-Carboniferous System), tufaceous red shales and green tuffs contain innumerable small scales of metallic copper, together with microscopic veins of the same metal. These strata are known as the Cupriferous Tuffs. Over 1.000 feet above these tuffs is a second series of green tuffs and chocolate-red shales. In the latter, at Long Reef, 12 miles north-east of Sydney, beautiful examples occur of plants resembling *Phyllotheca*, with their stems of brittle bituminous coal, held together in a delicate filigree-like network of metallic copper. Where the strata have been much weathered, the metallic copper passes into green and blue carbonates. The copper has obviously been derived from the decomposition of the basic tuffs. The tuffs are traversed in places by small veins of barytes.

The Hawkesbury sandstone, which is typically developed at Sydney and in the Blue Mountains, is chiefly formed of white to yellowish-grey sandstones, very regularly and evenly bedded, diagonal bedding being very conspicuous. South of the Hawkesbury River, in the area where this diagonal bedding dips to the north-east, primary graphite is scattered in scales or small pellets through the sandstone. To the north of the Hawkesbury River, the diagonal bedding dips in almost the opposite direction, that is from off the New England tableland, and this part of the formation does not contain graphite. Small garnets are not infrequent in the southern type of the Hawkesbury sandstone. Certain beds in this Stage form a valuable building stone, largely worked in Sydney and suburbs. It weathers, as the result of chemical changes in the iron carbonates, to a pleasing tint of warm sepia. A few bands of dark clay shale are interstratified with the sandstone. These often show evidence of having been disrupted contemporaneously, the fragments being up-ended so that their lamination planes are now vertical. Meanwhile, neither the sandstones above nor those below show any sign of disturbance. This phenomenon, together with that of contemporaneously contorted current-bedding, has been ascribed to the action of ice; but other explanations, such as that of undercutting of the clay shales by stream action are possible. These sandstones weather into picturesque shelter caves, as the result of the removal by capillarity of soluble mineral cement from the inner portion of the sandstone and its transference to the exterior. The Wiannamatta Stage is mostly formed of black carbonaceous shales, with at least one seam of coal, which, with clay bands, is about 4 feet thick. At the top of this stage the beds become sandy and calcareous, ending in a calcareous tufaceous rock, 100 feet thick, containing a very interesting foraminiferal and ostracodan fauna.

As regards fossil plants, *Thinnfeldia odontopteroides* is specially characteristic and abundant throughout the whole series. *Macrotænipteris* and *Phyllotheca* are also typical. *Sphenopteris* is also common, and in places is associated with *Alethopteris* (*Cladophebis*), but this last genus is much more characteristic, in Australia, of the Jurassic rocks than of the Triassic. Near the base of the Narrabeen Stage beautifully preserved specimens of *Schizoneura* are fairly common, and the genus not only extends downwards into the strata which form the roof over the Bulli coal seam, at the top of the Permo-Carboniferous System, but, at the Sydney Harbor collieries shaft at Balmain, Sydney, it has been found associated, in the same bed of clay

shale, with *Glossopteris*. *Schizoneura* has never been found in either the Hawkesbury or in the Wiannamatta Stages, but it occurs in Victoria in strata conformably overlying the *Gangamopteris* sandstones and glacial beds at Bacchus Marsh, to the west of Melbourne.

Stems of trees are numerous in the tuff beds near the top of the Stage, as well as forms allied to *Baiera*. Fossil fruit are plentiful in these beds at Long Reef and Narrabeen, to the north of Sydney. Reference has already been made to the abundance of *Phyllotheca*, some stems of which are partly encrusted with metallic copper. The lower part of the Narrabeen Stage, for about 500 feet above the top of the Permo-Carboniferous System, is swarming in small black valves of several species of *Estheria*. Just at the top of the Narrabeen Stage, or possibly a few feet up into the Hawkesbury Sandstone Stage, is a bed of shale at Gosford, which has proved exceptionally rich in remains of fossil fish, together with remains of small labyrinthodonts. The principal forms found are *Palæoniscus*, *Myriolepis*, *Cleithrolepis*, *Apateolepis*, *Dictyopyge*, *Belonorhynchus*, *Semionotus*, *Pristisomus*, *Pholidophorus*, etc.

In the Hawkesbury Sandstone Stage a problematical fossil plant, *Ottelia præterita*, occurs sparingly. In the occasional intercalated shale beds *Oleandridium* has been recorded, while *Thinnfeldia odontopteroides* is very abundant. The leaves are so well preserved that they are sufficiently coherent and flexible to be lifted off the surface of the shale, and when subsequently examined under the microscope, are seen to have preserved much original structure.

At Biloela (Cockatoo Island), near Sydney, a thoracic plate of *Mastodonsaurus* was found, and also, strange to say, at the same spot, a specimen of *Tremanotus*. This Silurian genus on a Triassic horizon may represent either a remarkable survival, or it is possible that the fossil may be an erratic in this formation. It is preserved in ironstone, which may have replaced a small fragment of limestone. In the shales of the Wiannamatta series, most of the fossils are either at the base or near the top of the Stage. Just as the Hawkesbury sandstone usually rests on an eroded surface of Narrabeen beds, so in the case of the junction line of the Wiannamatta shales, with the Hawkesbury sandstone there is in many cases evidence of contemporaneous erosion. A good deal of concretionary clay ironstone has formed in the basal beds of the Wiannamatta shales, and these are mostly fossiliferous. In addition to *Thinnfeldia* and *Phyllotheca*, the *Cycadopteris scolopendrica* has been recorded from these beds. True cycads appear on the whole to be wanting throughout the whole of the Australian Triassic rocks.

In the ironstone concretions referred to above, shells of Mollusca are often very abundant, belonging to the genera *Unio* and *Unionella*. The dwarf character of these shells suggests that the strata containing them were deposited in brackish water. In the brick-pits of Newtown and Enmore, in Sydney, numerous well-preserved specimens of fossil fish have been obtained. These range in size from a few inches up to specimens 6 feet in length.

Labyrinthodont remains have been found on this horizon, both at Enmore and at the Gib Rock Tunnel, near Bowral.

The specimen discovered at the former locality measures about 10 feet in length. Its immense jaws are furnished with three rows of powerful

conical teeth. The original specimen, preserved in clay ironstone, has never yet been described. It is now at Brisbane, in the possession of the Government Geologist of Queensland, who also has several as yet undescribed fossil insects, discovered by him in these shales. The Wiannamatta Stage closes with a bed of greenish tufaceous and calcareous sandstone, passing into sandy limestone. This is largely formed of foraminiferal and ostracodan shells. Comment has been made on the fact that, in this horizon of the Wiannamatta Stage, we have a remarkable example of the survival of a Silurian type of ostracod in the genus *Beyrichia endothyra*; also on this horizon is an interesting survivor from the carboniferous fauna. On the other hand, the genus *Haplophragmium*, which also occurs on this horizon, is not known elsewhere to descend so low stratigraphically.

The geographical conditions under which the strata of the Hawkesbury series were accumulated appear to be those of a large shallow lake close to the sea, with which possibly there was intermittent communication. The *Gangamopteris-Glossopteris* Flora of the Permo-Carboniferous Ice Age had, with the exception of *Phyllotheca*, *Sphenopteris*, and perhaps *Alethopteris*, completely disappeared before the earliest strata were deposited in this great lake basin. The eruptions, perhaps of the Kiama-Cambewarra region, or at all events of that zone, were prolonged into Triassic time, as proved by the frequent beds of basic tuff in the Narrabeen Stage. The evidence of ripple-marks and suncracks on many horizons all through the series points obviously to shallow water conditions. The foraminiferal ostracodan sandy limestone and calcareous sandstone at the top of the whole series prove that after a subsidence near the centre of the basin of about 3,500 feet, marine, or at least estuarine, conditions supervened. The flora of these Triassic rocks differs from the Jurassic in the presence in the former of *Phyllotheca* in vast numbers and of *Oleandridium*, while the *Tæniopteris daintreei* and varieties of cycads so common in the Australian Jurassic rocks are wanting in the Trias. Triassic types of *Estheria* do not ascend into the Jurassic, neither do the labyrinthodonts.

Endothyra, *Beyrichia*, *Tremanotus* (?), and *Palæoniscus* all represent Palæozoic forms of life surviving into Mesozoic time in the Trias of Australia.

In reference to the Fingal Series, and other representatives of the upper coal measures of Tasmania, some doubt exists as to whether they are to be classed as Upper Trias, perhaps Rhætic, or Lower Jurassic. As *Tæniopteris daintreei* (*T. spathulata*) regarded as a critical form in Australia for differentiating the Jurassic from the Trias has never yet been found in Tasmania, and the genus *Phyllotheca* is of common occurrence in these Tasmanian coal measures, it is proposed to class them provisionally as Upper Trias, or Passage Beds into the Jurassic proper. *Thinnfeldia odontopteroides*, *Alethopteris* (*Cladophebis denticulata*) *australis*, *Tæniopteris tasmanica*, *T. morrisiana*, *Phyllotheca*, and *Zeugophyllites* (*Phœnicopsis*, or *Podozamites*) *elongatus* are most characteristic. Other forms present are *Ptilophyllum oligoneurum*, *Sphenopteris lobifolia*, *Pterophyllum*, *Baiera tenuifolia*, *Ginkgophyllum australe*, etc. It may be stated generally that these Fingal coal measures are not as rich in fossil cycadaceous forms as are the true Jurassic rocks of the mainland. These measures, about 1,200 feet in thickness, are formed chiefly of yellow, brown, greenish, and bluish-grey

sandstones, with coal seams from 4 feet up to 20 feet in thickness. The coal is of fair quality, containing from 1 per cent. up to 4 per cent. of moisture, and from 9 per cent. up to 15 per cent. of ash.

(j) Jurassic System.

Rocks referable to this period belong to what was probably the greatest lake epoch through which the Australasian continent has passed. The principal lake extended from some point south of Dubbo to at least as far north as the far extremity of the Bunya Bunya Ranges of Queensland to the north-west of Dalby. It is probable that the lake extended still further up to the Cloncurry area. Westwards they stretch more or less continuously to Lake Eyre, and still further westwards to Lake Phillipson. The lake would thus have had a total length of 1,200 miles from east to west, with a width from north to south of 700 to 800 miles.

The strata deposited in this lake, or chain of lakes, are the main source of supply of the artesian water in the great artesian basin.

They vary in thickness from 300 to 400 feet up to, at Lake Phillipson, about 3,000 feet. Eastwards the basin extends through a narrow neck near Brisbane (*vide* Plate III.) to the coast at the mouth of the Brisbane River, and also by a wider passage to the east coast, along the basin of the Clarence River, between Ballina and Woolgoolga. That there is no outlet of consequence, if any, for the artesian basin in this direction is proved by the fact that a bore has been put down to a depth of over 3,000 feet at Grafton, and only a feeble trickle of artesian water has been tapped The same remark applies to the bore at the race-course at Brisbane. As details of this artesian basin are given by Mr. E. F. Pittman in his chapter in this volume, only very brief references will be made to the subject here. The section (Plate VI.) shows somewhat arbitrarily the line of junction between the Jurassic and the Cretaceous rocks, and is to be regarded as provisional only, as, on account of most of the bores being carried out by percussion, the fossils in the strata passed through are usually in such a fragmental state that identification is often very difficult.

The section (Plate VII.) shows the hydraulic grade descending from Charleville as a centre northwards to the Gulf of Carpentaria, and south-westwards to Lake Eyre. This fall in the hydraulic grade is difficult of explanation. The difficulties are obvious from the section, which shows that at its south-western end the basin is apparently blocked by impervious Pre-Cambrian or older Palæozoic rocks, so that apparently it has no outlet in that direction. Then, too, towards the north, a sill of older rock rises so high above the general floor of the basin that it would seem to go far towards checking any important underflow and outflow to the sea in this direction also. The explanation of the fall of the hydraulic grade seawards from Charleville, in Queensland, would seem to be either (*a*) that there are narrow subterranean outlets (which have not yet been tapped in the bores), both in the direction of the Bight and in that of the Gulf of Carpentaria; or (*b*) that before the bores were sunk the chief outlet for the artesian water was through those natural artesian wells—the Mound Springs. These are very numerous on the Lower Flinders River in the north, and near Lake Eyre towards the south-west end of the basin.

PLATE VI

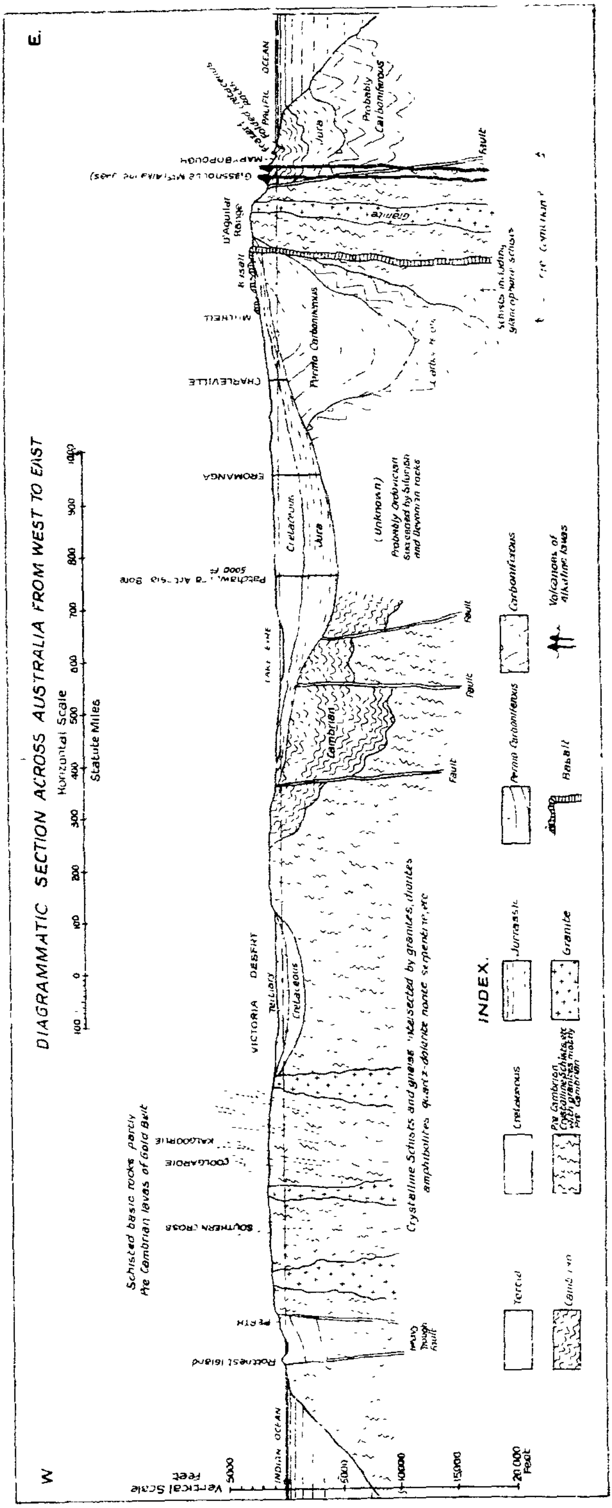
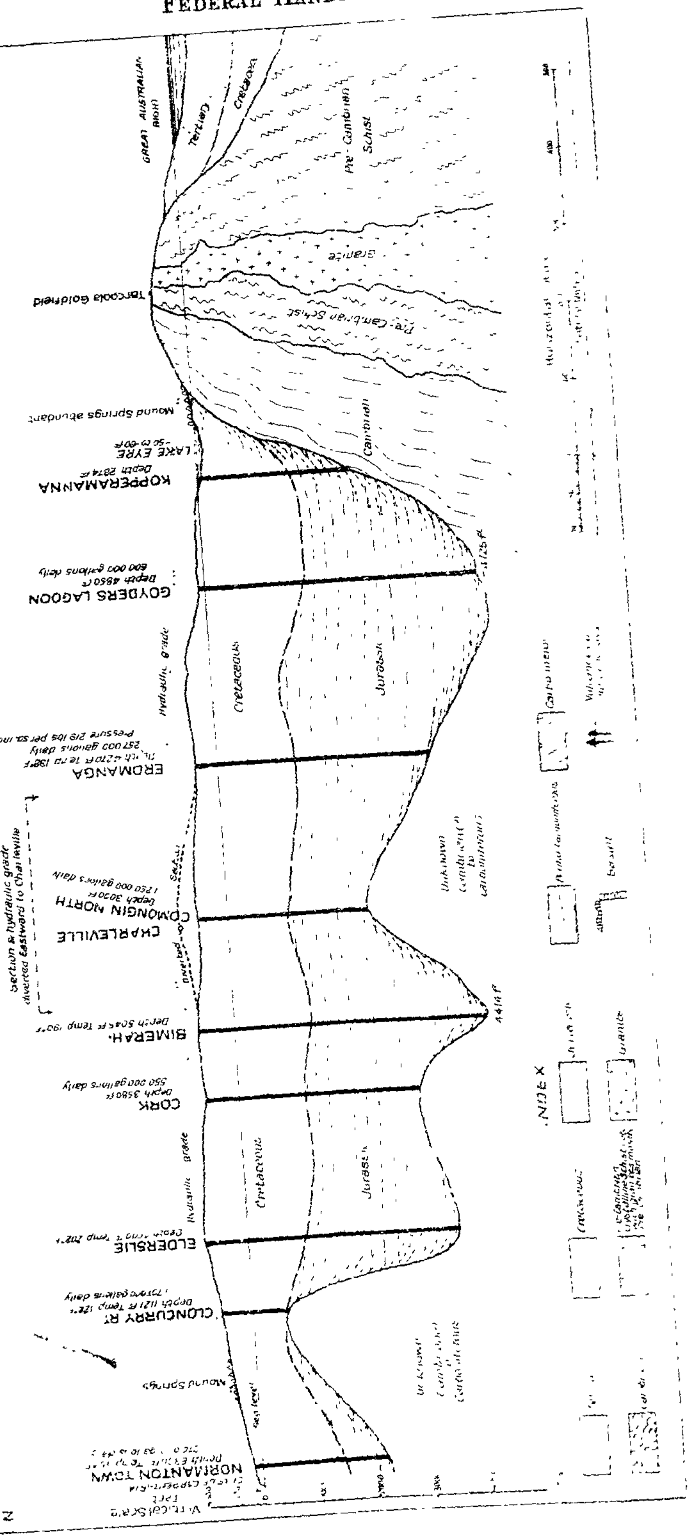

DIAGRAMMATIC SECTION ACROSS AUSTRALIA FROM WEST TO EAST
Horizontal Scale
Statute Miles
Vertical Scale
Feet
W
E
INDIAN OCEAN
Rottnest Island
PERTH
SOUTHERN CROSS
COOLGARDIE
KALGOORLIE
VICTORIA DESERT
LAKE EYRE
EROMANGA
CHARLEVILLE
MITCHELL
D'Aguilar Range
MARYBOROUGH
PACIFIC OCEAN
Schisted basic rocks partly Pre Cambrian lavas of Gold Belt
Crystalline Schists and gneiss intersected by granites, diorites amphibolites quartz-dolerite norite serpentine, etc
Tertiary
Cretaceous
Cambrian
Fault
Jura
Permo Carboniferous
Probably Carboniferous
Basalt
Granite
INDEX.
Jurassic
Carboniferous
Volcanoes of alkaline lavas

PLATE VII.

SECTION ACROSS ARTESIAN BASIN FROM GULF OF CARPENTARIA TO GREAT AUSTRALIAN BIGHT.



That springs connected with faults supply part of the artesian water is obvious; but it is probable that by far the larger proportion has a meteoric origin, being derived from rain falling direct on to the outcrop of the porous beds, or leaking into them from the channels of rivers.

This supposition receives some confirmation from the Cainozoic analogue of the artesian basin at Perth, in Western Australia, where the interdependence between rainfall and the outflow of artesian water has been distinctly proved: but the conditions in the Perth artesian basin are not in every respect analogous to those in the central Jurassic basin. For example, in the latter the factor of gas pressure is very important in helping to force the artesian supply to the surface. Over 90 per cent. of the gas concerned in producing this pressure is nitrogen: gases like CH_4, CO_2, H_2S, etc., are present in far smaller proportion. This nitrogen is almost certainly not of plutonic origin, but is probably derived from the alteration of organic material, such as lignite or coal, by the action of anærobic bacteria. As, however, the temperature of the artesian water is in some cases up to 204 degrees Fahr., even when the water arrives at the surface, it is difficult to understand how bacteria can live under such conditions. But, so far, the waters from the chief bores which evolve nitrogen have much lower temperatures than the above. This interesting problem, as indeed that of the whole physics, chemistry, and geology of the great artesian basin, still awaits solution. The total depth of all the artesian bores of Australia, according to the latest figures available to the writer, is almost exactly 500 miles, and the potential daily yield about 680 millions of gallons.

Strata of Jurassic age are also found on the eastern periphery of Australia and in Tasmania, as well as in the coastal regions of Western Australia.

In Queensland the principal localties are Ipswich, Clifton, Callide Creek west of Gladstone, Stanwell, and Rosewood west of Rockhampton, and Broadsound to its north. The strata are there from 2,000 to at least 3,000 feet in thickness, and consist of sandstones, conglomerates, and shales, with massive beds of quartz-trachyte tuff at the base of the Series at Brisbane. Basic lavas are present on a higher horizon and contemporaneous trachyte lavas. These are found between Brisbane and the Macpherson Ranges, on the borders of New South Wales and Queensland. The seams of coal in the Queensland Jurassic rocks range from a few feet up to a maximum of 30 feet in thickness. In the Ipswich basin the seams vary from about 6 feet up to 8 or 10 feet in thickness. The principal fossils are *Tæniopteris daintreei*, *Thinnfeldia odontopteroides*, *Alethopteris australis*, *Sagenopteris*, *Ptilophyllum*, *Podozamites kidstoni*, *Otozamites*, *Brachyphyllum*, etc. The fossil fauna comprises *Estheria mangaliensis*, *Unio ipsviciensis*, *Unio eyrensis*, while insects are represented by *Mesostigmodera typica* and several as yet undescribed forms.

In the Clarence Basin of northern New South Wales, strata of this age are probably at least 4,000 feet in thickness. They are divided into Upper Middle, and Lower Clarence Stages respectively. The Lower Clarence Stage contains several seams of coal, up to a maximum thickness of about 37 feet, but the seams are so full of clay bands that they are not at present worked commercially. The Middle Clarence Stage is a strongly marked horizon of massive diagonal-bedded sandstone. The Upper Clarence consists of clay,

shales, and clayey sandstones. A rich flora is contained in the Lower Clarence Stage, but it has not yet been described. *Tæniopteris daintreei* and *Thinnfeldia odontopteroides* are the most characteristic fossils.

A small isolated patch of Jurassic rock also occurs at Talbragan, between Mudgee and Dubbo, in New South Wales. These strata, which rest on an eroded surface of Hawkesbury sandstone, contain the following fossils:—*Tæniopteris daintreei, Alethopteris australis, Thinnfeldia falcata, Podozamites lanceolatus,* and *Baiera bidens*. Insects were represented by an ancestor of the true locust, the fossil form being described as *Cicada lowei*.

Amongst the fish, which are very numerous, are *Leptolepis gregarious, Archæomene robustus, Coccolepis,* etc.

In Victoria there are three considerable areas of Jurassic rocks—those of South Gippsland, the Cape Otway District, and the neighbourhood of Merino, in the west.

The strata consist of felspathic sandstones, with abundant fresh fragmental felspar, perhaps of tufaceous origin, besides shales, mudstones, and seams of coal. The seams are worked commercially in the Cape Paterson District, as at the State-owned colliery at Wonthaggi. The coal is of fairly good quality, and the thickness of the seams varies from 2 to 9 feet. The following are among the most characteristic fossils:—*Coniopteris hymenophylloides* var. *australica, Cladophlebis denticulata* var. *australis, Sphenopteris ampla, Thinnfeldia odontopteroides, T. maccoyi, Tæniopteris spatulata* and vars. *daintreei* and *carruthersi, Podozamites barklyi, Ginkgo robusta, Baiera subgracilis, Palissya australis, Brachyphyllum gippslandicum, Unio stirlingi.* The interesting discovery has been made of a tooth of *Ceratodus* from Cape Paterson, *C. avus*. Scales of *Ceratodus* have also been described from the parish of Killak, South Gippsland. *Ceratodus* has of course been recorded from the Stormberg series of South Africa, as well as from the Trias of Europe. Another recent very interesting discovery has been that of a claw of a dinosaur also in the Cape Paterson beds.

In South Australia, to the south of Lake Eyre, there is a small Jurassic coal basin, an outlier of the main Jurassic artesian basin, and preserved in a deep trough fault. This is the Leigh's Creek coal basin. Its strata of sandstone and carbonaceous shales are over 2,000 feet in thickness, and comprise several seams of coal, one of which is 47 feet in thickness. This coal is a hydrous brown coal. The chief fossils are *Thinnfeldia odontopteroides, T. media, Macrotæinopteris wianamatta Podozamites lanceolatus,* and an immense number of the fossil pelecypod *Unio eyrensis*. This occurred in almost every foot of the core from the bore for coal, from the surface to a depth of over 1,500 feet The only marine equivalents of strata of Jurassic age within the Commonwealth are found on the west and south-west coasts of Western Australia. They are chiefly developed in the Northampton District, extending thence by way of the Greenough River to Gingin, about 40 miles north of Perth, in Western Australia. The strata consist of white sandstones, ferruginous sandstones, light-coloured claystones, grits, limestones, and shales, with lignites. Their maximum thickness is quite 3,000 feet. In places phosphatic green-coloured patches in the ferruginous sandstone contain the phosphatic mineral dufrenite. Artesian water has been struck in this formation at Dongara and at Yardarino; but after flowing for

a few years, the flow has ceased at the former locality through the bore becoming choked, and at the latter through failure of the supply. The following are the most typical fossils in this area :—*Otozamites feistmanteli*, Zigno, *Pagiophyllum* (?), *Pentacrinus australis*, *Trigonia moorei*, *Teredo* found in its own bores in fossil wood, several varieties of Jurassic ammonites, and remains of large enaliosaurians. The second area commences at Cape Riche, and extends to beyond the Phillips River. The strata, in almost horizontal beds, rise to about 700 feet above sea-level. Perfect specimens of fossil sponges are weathered out from some of the caves in this formation.

A very important unit in the geology of Tasmania is the huge sills of diabase (granophyric dolerite and enstatite-augite dolerite), often over 500 feet thick, which have been intruded into these coal measures. They are almost certainly Pre-Cainozoic. If they are of the same age as the great dolerite sills of the Karroo System of South Africa, and the Antarctic dolerites, which intrude the Beacon sandstone formation of the Ross Sea Region, they should probably be placed at the top of the Jurassic, and perhaps be connected with the breaking up of Gondwana Land, at the close of Jurassic time.

(k) Cretaceous System.

This system is divided at present into the Rolling Downs formation below, and the Desert Sandstone above. The lower formation is almost wholly marine, except in the case of the Burrum coal-field of Queensland with the adjacent Frazer Island, or Great Sandy Island, and intermediate islands, which consist partly of fresh-water beds. The Desert Sandstone is mostly of fresh-water origin ; but in places, as at Croydon, in Queensland, it contains in abundance *Rhynchonella croydonensis*, and at Fanny Bay and adjacent areas at Darwin is represented by a radiolarian shale, and by cherts containing casts of small *Belemnites*. As regards thickness, the Desert Sandstones vary from about 150 feet up to a maximum of 500 feet, while the Rolling Downs beds are known to be in places about 2,000 feet in thickness, perhaps more. The exact thickness is not always easy to determine, on account of a nearly conformable downward passage from the Rolling Downs beds into the Jurassic strata. The vast extent, about one-third, of the whole area of Australia, formerly covered by the rocks of the Cretaceous system, shows that an enormous transgression of the ocean took place at this time, so as to develop a distinct epicontinental sea over the whole of the east central portion of Australia. Cretaceous rocks are also known to be developed on the north-west side of the Victoria Desert in Western Australia, as well as under the Tertiary limestones of the Nullarbor Plains fronting the Great Australian Bight, as lately proved in the Madura artesian bore. They are also represented by a narrow strip, some thousand feet below sea level, at Perth, as shown by the Clermont Bore as well as by a similar strip extending along the coast from north of Geraldton towards North-west Cape.

Mr. W. S. Dun, in his palæontological notes in this article, comments on the fact that the marine fauna from this west coast belt of Western Australia is closely allied to the Pondicherry Cretaceous fauna of India, whereas that of the great artesian basin represents a peculiar type locally developed within this Australian Mediterranean. Lithologically the Desert Sandstone rocks

consist mostly of coarse sandstone, passing in the arid regions into quartzite, as well as of very siliceous white shales graduating superficially into porcellanite, and in places containing valuable deposits of precious opal. The latter are associated with remarkable large forms, known to the miners as "pineapples," formed of common opal pseudomorphous after glauberite, together with concretions locally known as buns of barytes. Near Port Mackay, in Queensland, trachytic tuffs are said to be associated with the lower beds of the Desert Sandstone. This is the only record of contemporaneous volcanic activity in the whole Cretaceous System in Australia. Small seams of coal, too thin to be workable, and numerous silicified trees occur in places in this formation. The Rolling Downs strata are mostly friable sandstones rich in foraminifera, and rendered green by glauconite. In addition, at the Burrum coal-field and at Maryborough and Frazer Island, sandstones and shales, with fossil plants and seams of productive coal, are now considered to be of Cretaceous age. The whole series is approximately 3,000 feet thick. The Burrum coal seams, of which about four are of workable thickness—that is, from 3 feet to 4 feet thick—contain coal of a brittle, bright, black, bituminous character, and remarkably free from ash, but too friable for export. The fossil plants recently recorded from this Cretaceous coal-field show that forms like *Trichomanites laxum*, *Thinnfeldia media*, and *Tæniopteris daintreei* survived over from Jurassic time. *Corbula burrumensis* and *Rocellaria terræ reginæ* are associated with the Burrum coal measures. This recent discovery of the survival of part of the Australian Jurassic fauna and flora into Cretaceous time is obviously of considerable importance. As regards the fossil fauna in the Rolling Downs beds well preserved remains of infusoria belonging to the *Tintinnoidæ* associated with diatoms and radiolaria have been found in fine-grained limestones at Mitchell, on the Maranoa River. The following is a list of specially characteristic fossils:—Foraminifera, in which the *Lituolidae* are strongly represented, *Purisiphonia clarkei*, *Pseudavicula australis*, *Maccoyella barklyi*, *Nucula quadrata*, *Cytherea clarkei*, *Belemnites australis*, *Crioceras australe*, *Lamna daviesii*, *Aspidorhynchus sp.*, *Belonostomus sweeti*, *Notochelone costata*, *Ichthyosaurus australis*, *Plesiosaurus macrospondylus*, *Eschna flindersensis*, etc.*

The general evidence points to a progressive submergence of the Australian Continent in Cretaceous time leading to an encroachment of the sea southwards through the direction of the Gulf of Carpentaria across to the Australian Bight. It is just possible that there may have been a narrow neck of land joining east Australia to Western Australia to the south of Lake Eyre. At all events the isolation, when the submergence was at its maximum, of east Australia from Western Australia, must have been nearly complete. The wide spread of the comparatively thin beds of the Desert Sandstone, mostly of fresh-water origin, indicate that, in Upper Cretaceous time, the Cretaceous seas were retiring from the Continental area, and lacustrine conditions were taking their place everywhere, except locally, as at Croydon and Darwin. It may be added that Melville Island and Bathurst Island, to the north of Darwin, are formed of Cretaceous rocks, apparently of Rolling Downs type.

* This insect is probably an *Eschnidium*. Mention may here be made of an extraordinary fossil perhaps allied to *Eschnidium* now to be seen at the Geological and Mining Museum, Sydney. It is a well preserved wing in the heart of an immense selenite crystal found at over 600 feet underground in the Mt. Elliott copper mine near Cloncurry, Queensland.

but little is as yet known of their fossil contents. The fact that Lower Cretaceous fossils, especially small specimens of *Scaphites*, are being constantly washed up on the beach at the Point Charles lighthouse. Darwin, shows that Lower Cretaceous rocks underlie the strait which separates Melville Island from the mainland. It may be suggested here, very tentatively, that the vast transgression of the Cretaceous sea was perhaps causally connected with two other important geological events, viz.:—Firstly with the sinking in of Gondwana land leading to compensating uplifts of the sea floor, and secondly with the wholesale injection of the vast dolerite sills, which probably further contributed towards shoaling the ocean basins.

(I) Cainozoic Era.

The classification and correlation of the rocks of the Commonwealth belonging to this era present many difficulties.

It is harder in Australia than in Northern Europe to separate the Post Tertiary from the Tertiary rocks, as whereas in Northern Europe glacial deposits, chiefly of Pleistocene time, are widespread, in Australia such glacial evidences are wholly restricted to an area of less than 500 square miles, which has its centre at Mount Kosciusko. Only in Tasmania can evidences of Pleistocene ice action be traced over a large area. Then in regard to the correlation of the Australian Tertiaries with those of Europe, the statement of an Australian palæontologist still applies :—" Many attempts have been made to fit the Tertiaries of Southern Australia into the British Procrustean subdivisions, and I do not know that the results are any more satisfactory to the strata than they were to the guests of Procrustes himself."

Direct comparison of Australian Tertiary forms with those of Europe may prove fallaceous, unless supplemented by other evidence, for there is no direct proof of the existence of any highway for migration of marine organisms from the seas of the Southern Hemisphere into the Tethys area in early Tertiary time.

Tested by the Lyellian method—the determination of the percentage of recent Mollusca in the series—the Tertiary marine faunas of Australia can be compared with the recent fauna of Australian seas, but it is now clear that some Australian palæontologists who worked on these lines did not recognise the fact that in many of the older Tertiary deposits of Australia the marine molluscan fauna is not, as was originally supposed, littoral in habit, but belongs to a moderate depth ; and recent dredging operations have demonstrated the fact that many forms in the older Australian Tertiaries, formerly thought to belong to extinct species, are now living at some depths off the Australian coasts. If one relies for correlation on the evidence of wide-ranging and rapid-moving types, like sharks and whales, it may be noted that *Carcharodon angustidens* and *C. megalodon*, of the older Australian Tertiaries, are characteristically Miocene in the Northern Hemisphere. Then, too, the toothless whales of the Victorian older Tertiaries belong to a group which in the northern hemisphere appears to be chiefly Pliocene.

On the whole the tendency of late has been to refer the so-called Eocene strata of Southern Australia to some part of Miocene time. Recently it has been proposed to divide the Tertiary rocks of Victoria into three systems, details of which are given in this article. It will be seen that reliance is

largely placed for purposes of correlation on various species of *Lepidocyclina*. Meanwhile the sequence of events in Cainozoic time in Southern Australia and Tasmania, from the close of Cretaceous time, may be briefly stated as follows :—

1. Accumulation of plant-bearing strata, developing in places into thick beds of lignite. These plants have been considered to be Eocene, but may be Oligocene or Lower Miocene. A primitive marsupial fauna was probably already in occupation of Tasmania, as a nearly complete skeleton of *Wynyardia* has been found in the marine strata of No. 3, which conformably follows No. 2, No. 2 being conformable to No. 1, and all being separated from one another by no great time interval. *Wynyardia bassiana* was a generalized form neither distinctly polyprotodont nor distinctly diprotodont. (The original is now in the Hobart Museum.) The older "deep leads" of Eastern Australia belong here

2. Extensive flows of the so-called "older basalts," and development of basic tuffs passing into laterite and covering the older deep leads.

3. The Pre-Miocene Bassian landbridge between Tasmania and the mainland became broken down, the old bridge becoming involved in a general submergence, which affected the whole of the southern shores of Australia. In the Nullarbor Plains area of the Great Australian Bight, strata of white chalky limestones, with flints, and often rich in *Gryphaea*, were developed over a large area. Similar strata occur at intervals all along the southern shores of Australia. In the Lower Murray area, as well as in Victoria and Tasmania, the polyzoon *Cellepora gambierensis* is extremely characteristic, and in the cliffs of the Lower Murray forms sub-spherical masses, each of the size of a man's head. These strata attain a thickness of about 80 feet at Table Cape, Tasmania, and on the coastal plains of Southern Australia are usually 200 to 400 feet thick, with a maximum thickness of about 1,000 feet under the Nullarbor Plains. The Purari series and the oil-bearing strata of British New Guinea probably are of this age.

4. The *Ostrea sturti* beds, which overlie the *Cellepora* limestones of the Lower Murray, perhaps Upper Miocene.

5 The immense belt of alkaline lavas and tuffs, which extend from Casterton, in Victoria, through Mount Macedon to Clermont and Springsure, in Queensland, perhaps belongs to this horizon.

Possibly the nepheline-basanite of Table Cape, the melilite basalt at Sandy Bay, near Hobart, and the nepheline melilite basalt and nepheline eudialyte basalt of Shannon Tier, in Tasmania, were erupted about this time.

6. In British Papua the Port Moresby series probably belongs to the older Pliocene. In Australia Marine Pliocene strata, to a thickness of about 1,000 feet, were deposited in the neighbourhood of Adelaide, as proved by the Croydon bore (2,296 feet deep). In all other areas in Australia and Tasmania, strata of this age are of freshwater or of volcanic origin. Possibly the lake beds of the Launceston Tertiary Basin, 1,000 feet thick, are of Pliocene age, as they contain fossil fruits, such as *Spondylostrobus smythii, Plesiocapparis leptocelyphis, Pentrune allporti*, etc., fossils more characteristic of the Kalimnan than of either the Janjukian or of the Balcombian age.

7. Vast sheets of basalts, proceeding from dyke eruptions, flooded the nearly even surfaces of the east and south-east Australian and Tasmanian peneplains. In South Australia they are represented at Kangaroo Island, and in Western Australia at Bunbury, the Lower Blackwood River, and at Black Point upon the coast. The fact that the flora of this period shows scarcely any trace of differentiation suggests that the land had a low relief. These extensive basaltic outflows appear to date near to the close of Pliocene time.

8. (*a*) In either very late Pliocene, or early Pleistocene time, the earth's crust, in the Australian and New Guinea region, was subjected to considerable diastrophism. The eastern periphery of Australia, including Tasmania, was warped up to altitudes of over 3,000 feet above the sea. The movement being differential carried an area, such as Kosciusko, to a height of 7,000 feet above sea level. In New Guinea the Cretaceous to Pliocene strata underwent intense orogenic movements, mountains being produced up to and over 15,000 feet in height.

(*b*) A glacial age supervened, which had many phases. Kosciusko was capped by an ice calotte from its summit to about 5,000 feet above sea level. In Tasmania the glaciation was naturally very heavy on the west coast and western highlands, the modern heavy rainfall, coming from the west, being at that time largely replaced by snowfall. Not only were the Western Tiers of Tasmania and the highlands of the west coast covered with firn-fields and glacier ice, but at the township of Gormanston glacial boulder clays were formed only a few hundred feet above sea level, and on the west side of the Craycroft Range the moraine material descends to within 250 feet of sea level. This glaciation affected, probably synchronously, New Guinea, and it was probably during a phase of this glacial age that the rhododendron migrated from Papua to the Bellenden-Ker Range, of Queensland (over 5,000 feet high), where it has since become isolated through the amelioration of the climate. The phenomena of the maximum glaciation seem to call for a lowering of temperature of approximately 9 degrees Fahr., as compared with that of the present day.

(*c*) Partly synchronous, if not wholly synchronous, with this Ice Age, or possibly its interglacial phases (if there were any such), was an epoch when the central plains of Australia had a good rainfall, and the present area of internal drainage was only beginning to come into existence. Great herds of herbivores, of much larger size than their nearest modern allies, roamed over what are now the arid regions of the lower steppes of Australia, near Lakes Eyre, Frome, and Callabonna. This fauna comprised *Ceratodus*, *Megalania prisca*, *Meiolonia*, *Pallimnarchus pollens*, *Diprotodon*, *Nototherium*, *Macropus*, and *Sceparnodon*, with the probably carnivorous form *Thylacoleo*, and the carnivorous *Thylacinus*, *Sarcophilus*, and *Canis dingo*, while *Sus papuensis* found its way southwards from Papua, as far as the Darling Downs, of Queensland. Thus during this Kosciusko epoch Papua was still united to Australia, and the recent discovery of a *Nototherium* (*N. tasmanicum*, Scott) at Mowbray Swamp, in the north-western part of Tasmania, taken in conjunction with other evidence, suggests that Tasmania was once more united to Australia by way of the Bassian Bridge. At least one gigantic ancestor

of the emu *Genyornis* was associated with this fauna. This bird was probably about 13 feet in height. A fine collection of this fauna is in the Adelaide Museum.

(*d*) Subsidences complementary to the uplift no doubt commenced with the uplift, but became much more pronounced after the uplift ceased. The rift valleys, Torres Strait, Port Curtis, of Cairns, of Cooma, of Bass Strait, Hobart, Port Phillip, St. Vincent and Spencer's Gulfs, and Lake Torrens, and of the west coast of Western Australia gradually developed, together with those many faults traversing the highlands of the warped peneplains of Australia and Tasmania, whose unreduced scarps attest their comparatively recent origin. The recent volcanic craters of Mount Gambier, Tower Hill, etc., may be referred to this epoch. Possibly negritoid man entered Tasmania by way of the Pleistocene Bassian Bridge before its final collapse. Ever since the Kosciusko epoch canyon cutting has been proceeding down to the present day in the elevated peripheral portions of Australia and Tasmania, this process tending to push the divides further inland.

Amongst recent formations may be mentioned the dune rock, partly cemented by lime, of Fremantle, and the south-western coast of Western Australia, of Cape Northumberland, near the border of South Australia and Victoria, and the dune rock of Warrnambool, Sorrento, etc. At Sorrento this dune rock is about 1,000 feet in thickness, and near Perth, in Western Australia, is at least as thick. The heavy silting along the Victorian coast, which has produced the Gippsland Lakes, as well as silting off the Maryborough coast, where the dunes are 800 feet high, and the silting between Sharks Bay and North-west Cape, in Western Australia, are all connected with the cusps of slack water formed next the shore, where great ocean currents meet. Mention may also be made here of the sand dunes of the lower steppes of Australia, and of the Victoria Desert. The latter are only superficially formed of loose sand, to a depth of a foot or so, and then the formation passes into a tough calcareous rock. The Transcontinental railway from Perth, by way of Kalgoorlie to Adelaide, will have to be cut through a vast number of these dune ridges, which are from 30 feet up to 80 feet high in places. In the Lake Eyre region the sand dunes again are only superficially loose sand. Inside they are formed of a certain amount of loamy material, especially near the old deltas of Cooper's Creek, and of the Diamantina River. In most parts of Central Australia these dunes derive their sand from the breaking up of the Upper Cretaceous desert sandstone.

In addition to the alluvial plains and rivers, mention may be made of the laterites (pindan gravels) of Western Australia, the nodular tufaceous limestone ("kunkar") of South Australia, the saline deposits of the inland plains, and the coastal salinas. Subsidence has evidently been recently in progress at the southern end of Tasmania, and the large "bank" recently discovered 200 miles further south, is obviously an immense sunken segment of a once greater Australia. Submergence has also taken place for a great distance along the east coast of Australia. As already stated, this is partly due to the recent melting of ice and snow in Antarctica, bringing about a eustatic positive movement of sea level; but it cannot be entirely due to this, as the recent submergence is in places of the order

of fully 200 feet, and it is doubtful whether the ice of Antarctica, from the great ice age down to the present time, can have affected sea-level to the extent of more than about 100 feet.

The so-called raised beach of about 15 feet is so general around Australia, that it is probably due to a recent eustatic negative movement of the sea surface. The 50 feet raised beach near Darwin is probably connected with recent orogenic movements in Papua. These recent movements have caused a local emergence of the coral reefs in south-eastern Papua of 1,000 up to 2,000 feet. The Great Barrier Reef of Queensland, some 1,200 miles in length, represents, in its uppermost portion, a marvellous area of growing reef. The bulk of the reef appears to be formed of coral.

Earthquake shocks, most frequent in the area between the gulfs of South Australia, Bass Strait, and Kosciusko, show that coastal readjustment is still in slow progress in those regions. In New Guinea sharp shocks proceed from near the active volcanic zone, near Mount Victory. Most of the earthquake shocks which reach the eastern side of Australia emanate from the deep trench to the east of the Tongan and Kermadec Islands. Western Australia is practically free from earthquakes.

5.—Pre-Historic Man.

As is well known, the aboriginal inhabitants, now unfortunately extinct, of Tasmania belonged to the negrito and were in a palæolithic state of civilization. They had no knowledge of producing a cutting edge on stone by grinding it down on a hone stone, all their instrunents being of the rudest possible type, and roughly chipped. Neither had they any knowledge of building canoes of the sea-going type, being satisfied to construct them from the bark of trees stripped off in long sheets, then sewn up at the ends and plugged with clay. In this frail craft they navigated their own rivers and lakes. No trace has been found in Tasmania of aboriginal man considerably antedating the coming of the white man. On the mainland of Australia the aboriginal attained to neolithic stage of civilization as far back as we have any traces of him. Up to the present the following appear to be the only evidences of man in Australia attaining to anything approaching high geological antiquity:—

1. The Tasmanian aborigines probably crossed Bass Strait (as they were ignorant of the art of making sea-going canoes) by an almost continuous, if not continuous, land bridge.

2. On the mainland of Australia there is possible evidence near Warrnambool of impressions attributable to human bodies and feet in some of the old cemented sand dunes. Many have doubted the genuineness of these imprints. In New South Wales several stone tomahawks were dug up a few years ago in cutting a canal at Shea's Creek, between Botany Bay and Redfern. These tomahawks were embedded in peat many feet in thickness underlying marine estuarine beds at a total depth of 15 feet below the high water. It may be concluded that the whole of our coast-line has subsided by 15 feet, or else, as the result of the melting of ice and snow in the Antarctic regions, sea level has risen by that amount since the time when the aborigines lost their tomahawks in this swamp. In either case a

considerable lapse of time, perhaps of the order of several thousands of years, would be needed to account for this change in the relative level of land and sea.

3. Statements have frequently been made that stone tomahawks have been discovered in the deep leads of Victoria. The following, as far as is known, is the only case where the stone tomahawk may possibly be considered as the same age as a deep lead:—Near Maryborough, Victoria, in 1855, a basalt axe head was found at a depth of 4 feet from the surface in one of the tributaries of the main Bet Bet lead. The main lead is covered by basalt believed to be of Pleistocene age, but, as the tributary lead in which the axe head was found is not covered by basalt, the finding of an axe head at a depth of only 4 feet does not necessarily imply any great antiquity for it.

6. Australian Graptolites.

By T. S. Hall, M.A., D.Sc., Lecturer in Biology in the University of Melbourne.

Graptolites are found at innumerable localities in Victoria where Silurian or Ordovician rocks occur, but so far none have been found west of the meridian of Ballarat. The belt of old rocks is continued from eastern Victoria along the inland slopes of the Divide far into New South Wales, and during the last few years have yielded graptolites from a few places. Tasmanian records are vague, but some identifiable forms have been obtained from boulders in the Permo-Carboniferous glacial beds at Wynyard. There are no records from the other States, but Lower Ordovician species have been found in New Zealand.

Apparently the whole range of the fauna can be illustrated from Victoria, with perhaps the exception of Devonian and Cambrian forms. We can recognise the following subdivision of the rocks:—

Ordovician	Upper	
	Lower	Darriwillian
		Castlemanian
		Bendigonian
		Lancefieldian.

SILURIAN.—*Retiolites australis* McCoy and two or three species of *Diplograptidæ* and *Monograptus*, including *M. turriculatus*, have been found in Victoria, and *Monograptus* occurs in New South Wales.

ORDOVICIAN.—It has not been found convenient as yet to recognise the three usual subdivisions accepted in Europe, and we need only consider an upper and lower division.

The UPPER division is characterised by *Dicranograptus*, *Dicellograptus*, *Leptograptus*, *Nemagraptus*, *Didymograptus*, *Diplograptus*, *Climacograptus*, *Cryptograptus*, *Glossograptus*, *Lasiograptus*, *Retiograptus*, and *Retiolites*. The series is well represented in the eastern part of the State, and passes north into New South Wales, where Lower Ordovician is not as yet known to be represented. A large number of the species are new, but many northern hemisphere forms have been recognised. No detailed stratigraphical work has been done in these rocks.

The LOWER division has had more attention given to it, as it is displayed on many of our goldfields.

DARRIWILLIAN.—No good exposures are known and specific records are few. *Dicranograptidae* are absent. The following genera are represented :— *Didymograptus, Tetragraptus, Loganograptus. Diplograptus, Climacograptus, Trigonograptus, Glossograptus, Lasiograptus*, and others not determined.

CASTLEMANIAN.—The fauna is rich. *Didymograptidae* are well represented. *D. caduceus* Salter (= *D. gibberulus*) is abundant throughout, and passes up. *D. bifidus* and its allies are found only in the lowest beds, and pass down into the top of the next division. The relative position of these two species is peculiar and well proved in various localities.

BENDIGONIAN.—The most abundant fossil is *Tetragraptus fruticosus. Bryograptus* occurs in the lowest beds, though it is generally regarded as Cambrian in Europe. *Tetragraptus approximatus* Nicholson is also found at the base, and is in one locality associated with Lancefieldian forms. It is thus of stratigraphical importance. The Bendigonian fauna is rich in species.

LANCEFIELDIAN.—*Bryograptus*, several species of *Clonograptus* and *Dictyonema* occur. Lithologically similar rocks with the same fauna have been recognised by me from the south-west corner of New Zealand, more than 1,000 miles away.

There are several apparent inversions of the European sequence of species, and Ruedmann has shown that the Australian sequence is practically that of New York, and both agree in differing slightly from the European.

7. Notes on the Palæontology of Australia.

By W. S. Dun, Lecturer in Palæontology in the University of Sydney.

The general character of the fauna of the Palæozoic of Australia as a whole, is its cosmopolitan nature, no definite Australian fauna being presented until the Permo-Carboniferous.

CAMBRIAN.—Fossiliferous limestones and shales of Cambrian age occur in Western Australia, South Australia, Northern Territory, Victoria, and Tasmania. *Olenollus* beds with *Salterella* occur in the Kimberley District (W.A.). In Yorke's Peninsula (S.A.), Archæocyathinæ limestones are well developed, also beds containing *Micromitra, Kutorgina, Obolella, Nisusia, Eoorthis, Huenolla, Stenotheca, Ophileta, Salterella, Hyolithes, Dolichometopus, Conocephalites, Olenollus, Microdiscus, Ptychoparia.* At Beltana occurs the most important horizon of Archæocyathinæ so far discovered; eight genera and thirty-two species have already been described.

In the Northern Territory, from Ekeldra, *Agnostus, Paradoxides, Microdiscus*, and *Ptychoparia* have been recorded.

In Victoria, in north-eastern Gippsland, near Mount Wellington, occur limestones with *Plectorthis, Lingulella, Scenella, Agnostus, Ptychoparia*, and *Crepicephalus.*

The Heathcotian beds containing *Dinesus* and *Notasaphus* may prove to be either Cambrian or Cambro-Ordovician. In Tasmania Archæocyathinæ occur and quartzites yielding *Dikelocephalus* and *Concephalites.*

ORDOVICIAN.

In Central Australia Ordovician limestones contain *Endoceras*, *Orthoceras*, Asaphus spp., *Ctenodonta*, *Raphistoma*, and *Ophileta*.

In Tasmania the Gordon River limestones with *Cyrtodonta*, *Ctenodonta*, *Tellinomya*, *Bellerophon*, *Helicotoma*, *Hormotoma*, *Raphistoma* may prove to be of Silurian age. Ordovician brachiopods and trilobites are also found in the Florentine Valley.

SILURIAN.

The Silurian of Australia occurs entirely in the eastern States, and is of a true cosmopolitan type, and the fossiliferous limestones and shales of New South Wales and Victoria may be correlated with the Wenlock and Ludlow in part. There is an abundant molluscan, brachiopod, trilobite, and cœlenterate fauna, the main characteristics being the great variety of *Halysites* in New South Wales, of *Tryplasma*, *Spongophyllum*, and *Rhizophyllum*, and the presence of endemic rugosa such as *Mucophyllum*, *Mictocystis*, *Arachnophyllum*, *Vepresiphyllum*, etc.; *Conchidium* and *Barrandella* horizons are well developed in New South Wales.

DEVONIAN.

Devonian strata occur in Western Australia and the eastern States. In Western Australia, the Kimberley, Napier Range, and Gascoyne river beds contained a Lower or Middle Devonian fauna—Stromatoporoids, *Cyathophyllum*, *Phillipsastrea*, tabulate corals, *Atrypa reticularis*. Certain of the fossils recorded from these beds, however, belong to adjacent Permo-Carboniferous areas.

In Victoria, in Gippsland, Middle Devonian limestone with *Spirifera yassensis* and *Receptaculites* are well developed. Freshwater Upper Devonian or Lower Carboniferous beds contain *Archæopteris*, *Sphenopteris*, and *Cordaites*—these beds also occur in southern New South Wales.

In New South Wales the Lower Devonians are well developed in the Murrumbidgee District and are characterized by a great development of *Receptaculites*, one species attaining a diameter of at least a foot. Tabulate corals are abundant. The typical fossils are species of *Actinocystis*, *Diphyphyllum*, and *Spirifera yassensis*.

The Middle Devonian are developed in the Western Districts, and contain varieties of *Spirifera cristata* and pterinoid bivalves, etc.

The Upper Devonian sediments of New South Wales are of two types, the arenaceous of the Western Districts containing *Rhynchonella pleurodon*, *Spirifera disjuncta*, and *Lepidodendron*, *Lepidodendron australe*, and that of the New England District composed of coralline limestones, claystones, and cherts.

The limestones contain such corals as *Favosites*, *Heliolites*, *Sanidophyllum*, *Spongophyllum*, *Diphyphyllum*, and *Syringopora*—all species distinct from the Silurian and little in common with the Lower Devonian series. The limestones and cherts comprise a great development of interbedded Radiolarian rocks. The upper mudstones contain *Lepidodendron australe* in abundance.

In Queensland the Fanning River and Burdekin limestones are corralline and contain abundance of *Alveolites, Arœopora, Campophyllum, Stringocephalus, Atrypa,* etc.

CARBONIFEROUS.

Beds of this age occur in New South Wales, Victoria, and Queensland.

The Mansfield beds of Victoria, regarded as Lower Carboniferous, contain *Lepidodendron australe* and fish—*Gyracanthides, Acanthodes, Strepsodus, Elonichthys,* etc.—it is possible these beds may prove to be in part Upper Devonian.

In New South Wales, marine and freshwater Carboniferous beds occur. The marine fauna is of the mountain limestone type, and consists mostly of cosmopolitan types of brachiopoda, *Productus semireticulatus, Orthis resupinata, Spirifera striata, Phillipsia, Griffithides,* and *Brachymetopus.*

The coral fauna is typical—*Zaphrentis, Cyathophyllum, Lithostrotion, Michelinia,* etc.

Mesoblastus and *Tricoelocrinus* occur in Queensland

The freshwater beds have a Middle Carboniferous facies with *Aneimites ovata, Cardiopteris,* and *Lepidodendron veltheimianum*

In Queensland the Star beds, well developed around Rockhampton, have a fauna very similar to that of the New South Wales series

Doubtful Carboniferous beds containing *Lepidodendron* occur in Western Australia.

A fact of importance in Eastern Australia is that no Carboniferous species extend into the overlying Permo-Carboniferous, and that there is a well-marked unconformity between the two systems.

PERMO-CARBONIFEROUS.

Of the Australian Palæozoic faunas that which attracts most attention is the Marine Permo-Carboniferous, and the interest is twofold, due in the first place to the change which without doubt in great part effected the glacial phase which occurred at the initiation of sedimentation, and the effect of land barriers hindering migration between the eastern and western Permo-Carboniferous shores.

The Eastern Australian Permo-Carboniferous fauna may be regarded as exhibiting the typical Australian facies, containing as it does the development of many purely Australian types. The two main divisions of the marine sediments—the Lower and Upper Marine series (separated in typical localities by a freshwater phase—the Greta coal measures) vary little in character in New South Wales, Queensland, and Tasmania.

The principal elements of the fauna are—

FORAMINIFERA.—*Nubecularia, Pelosina, Hyperammina, Haplophragmium, Lituola, Endothyra, Lagena, Nodosaria, Geinitzina,* etc., etc. *Nubecularia* is in great abundance and the arenaceous and subarenaceous types preponderate. Horizons occur in both Lower and Upper Marines and in association with the Pokolbin (Lower Marines) horizon, and also in the Wollong (Upper Marine) are glacial beds, indicating the cooling of the water.

SPONGIDA. — Sponges are rare, the anchoring spicules of *Hyalostelia*, *Lasiocladia*, and certain burrowing sponges (*Clionolithus*) are found in the Lower and Upper Marines of New South Wales.

CŒLENTERATA.—One of the noticeable features of the Permo-Carboniferous of eastern Australia is the impoverished Cœlenterata fauna, due without doubt to the glacial conditions at the initiation of sedimentation. A few species of Zaphrentoid corals, close to Hinde's genus *Plerophyllum*, occur showing an extravagant development of stereoplasma. The tabulate *Trachypora* forms a well-marked zone fossil in the Upper Marines.

ECHINODERMATA.—This phyllum is of particular interest. Blastoids and cystoids are absent; the Crinoidea are represented by the giant *Phialocrinus princeps* of the Upper Marines, 4½ inches in diameter. *Tribrachiocrinus*, a dicyclic form with large radianal and "X" plate, three double branchia and two single—this genus is peculiar to Eastern Australia. A large *Archæocidaris* and several species of Palasterids (*Etheridgeaster*, *Monaster*, and *Palaeaester*) occur in the Lower Marines, one, *Etheridgeaster giganteus*, having a span of 7 inches.

BRYOZOA.—The great development of the trepostomatous *Stenopora* is a characteristic of this period in Eastern Australia. The massive *S. crinita* forms irregular polyzoaria of from 1 to 2 feet in size. Dendroid and flabellate types are also common and present many species as yet undescribed.

The Fenestellidæ are also well developed. *Fenestella* is rare, but such types as *Phyllopora*, *Polypora*, and *Protoretepora* being extremely abundant, and in some cases form distinct limestones in the Lower Marines. Fenestellidæ are equally developed in the Lower and Upper Marines and in all provinces.

BRACHIOPODA.—This may be regarded as a *Martiniopsis* fauna. This protean genus is extremely abundant in all suitable sediments. Associated with it are winged *Spiriferæ*, all strongly ridged, *Spiriferina dielasma*, *Chonetes*, *Productus*, *Strophalosia*, Aulosteges, Lingula, and Orbicula. In Queensland, in the Bowen beds, we get as well Derbyia senilia. It must be noted in contradistinction to the Permo-Carboniferous Brachiopod fauna of Western Australia and the Northern Territory that Carboniferous species are entirely absent and that there is an absence of the Orthidæ and *Leptæna* group, *Athyris*, *Cyrtina* *Syringothyris*, and *Reticularia*.

PELECYPODA.—It is in this group of the Mollusca that what may be termed the Pacific facies of the Australian Permo-Carboniferous asserts itself with purely endemic genera as *Cleobis*, *Mæonia*, *Astartila*, *Pachydomus*, *Notomya*, *Aphanaia*, *Merismopteria*, *Clarkia*, *Deltopecten*—a giant form, a transition between *Aviculopecten* and *Pecten-Stutchburia*, an edentulous variant of *Pleurophorus*. *Chænomya* (Meek) of the Nebraska-Permian is very characteristic

of certain estuarine deposits. The most interesting type is *Eurydesma*, mainly characteristic of the Lower Marines, noteworthy for its absence from Western Australia and its presence in the olive shales of the Himalayas, and the Marine Karoo of German West Africa. The fauna is noteworthy for the preponderance of edentulous gaping types. Cosmopolitan genera, such as *Nuculana*, *Scaldia*, *Cardiomorpha* (?), *Solecurtus*, *Aviculopecten*, *Solenopsis*, *Modiolopsis* also occur. The fauna is evenly distributed along the east coast.

GASTEROPODA.—There is nothing distinctive in the eastern Gasteropod fauna which includes *Platyschisma*, *Straparollus*, and various *Pleurotomarioids*—*Keeneia*, *Ptycomphalina*, *Mourlonia*, and a Naticoid type, together with a patelloid genus and *Orthonychia*.

PTEROPODA AND CONULARIDÆ.—*Hyolithes* is common, and a giant *Conularia* reaching a length of 20 inches, occurs in the eastern provinces.

CEPHALOPODA are uncommon, *Orthoceras* and *Agathiceras* (*Goniatites*) being abundant in the Ravensfield sandstone of New South Wales.

THE WESTERN AUSTRALIA FAUNA.

In Western Australia it has been customary to class certain formations as Carboniferous and certain as Permo-Carboniferous, but there is good reason to believe that the entire series, developed in the Irwin, Gascoyne, Mingenew, Minilya, Lyons River Districts, and Kimberley is more properly Permo-Carboniferous as regards the mingling of the faunas.

One of the prominent features of the Eastern Australian Permo-Carboniferous fauna is the absolute absence of any Carboniferous species, whereas in the west, together with Indian species and local varieties, there are Carboniferous types such as *Orthis resupinata*, *Rhipidomella*, *Productus semireticulatus*, *Leptæna analoga*, *Phillipsia*, etc.—forms which in Eastern Australia are confined to the Star beds of Queensland and New South Wales, beds separated from the Permo-Carboniferous of that region by a well-marked unconformity. Taking into consideration the fact that the so-called Permo-Carboniferous sedimentation of both eastern and western Australia was initiated by glacial stages which must be regarded as synchronous, this mingling of faunas in Western Australia points to a direct communication with the Permo-Carboniferous coast line of the Himalayan and Salt Range Region. The fact that certain Producti, Pectinidæ, Terebratulidæ, and Spirifeidæ of the West have a close resemblance to Eastern Australian types may, perhaps, be regarded as instances of parallel development, rather than of specific identity.

The Permo-Carboniferous of the Northern Territory has western affinities.

As regards the flora of the Permo-Carboniferous, nothing need be said other than that a Lower Gondwana flora is preserved in both Western and Eastern Australia. The earlier beds are characterized by Gangamopteroid types, the upper by *Glossopteris* and *Phyllotheca*, more especially.

MESOZOIC.

The Mesozoic rocks of Australia, fresh water and marine, range from Trias to Cretaceous.

The freshwater beds present in all the States are of Trias and Jurassic age, and in Eastern Australia there is good reason to regard the so-called Jurassic (Ipswich) system as being the freshwater series directly succeeded by the Marine Cretaceous.

In Western Australia fresh water beds of Jurassic age occur at Mingenew with *Otozamites* and *Plagiophyllum*. At Champion Bay *Belemnites, Dorsetensia, Stephanoceras, Trigonia*, etc., occur. At the Greenough River are Oolites yielding *Alectryonia Marshii*, *Ctenostreon pectiniformis*, *Radula duplicata, Trigonia*, etc. It is possible that the Gingin chalk is of Cretaceous age. The fauna of the Marine Mesozoic of Western Australia exhibit marked affinities (and identity) with European and Asiatic species.

In the Northern Territory, at Point Charles, there is evidence of an abundant Cretaceous fauna *Aucella, Scaphites, Histrichoceras*, etc., dwarfed forms in almost every case, and having Gault affinities.

Almost as marked as the difference between the eastern and western Permo-Carboniferous fauna is the lack of community between the Marine Mesozoic fauna of the east and west. Stratigraphical evidence points to the fact that there is a continuity of sedimentation from at latest Jurassic to the end of Cretaceous time, and this has led to an apparent mingling of faunas. The Cretaceous Mediterranean occupied portions of the States of Queensland, New South Wales, and South Australia, and is characterized by numerous species peculiar to the region and many endemic genera among the Mollusca. The most typical forms are *Maccoyella*, *Pseudavicula*, and *Fissilunula*, all endemic types occurring in both Lower and Upper Cretaceous. The cephalopodan fauna is not larger, but is noteworthy for the great size of the *Crioceras* and *Ancyloceras* group. *Icthyosaurus*, *Plesiosaurus*, and *Cimoliosaurus* are represented by several species. The nature of the fauna points to the fact that the barrier which prevented the mingling of the Eastern and Western Permo-Carboniferous faunas persisted into late Mesozoic time

The Mesozoic flora of Eastern Australia may be divided into three groups—(1) the Ipswich flora of Queensland, the Clarence basin of New South Wales, the South Gippsland basin of Victoria, and the Lake Eyre basin of South Australia, (2) the Tasmanian Upper coal measures: and (3) the Hawkesbury series of the Sydney-Blue Mountain District.

(1) The Ipswich, etc. series.—These beds possess the cosmopolitan Jurassic vegetation with *Cladophlebis denticulata*, various species of *Thinnfeldia*, *Tæniopteris daintreei*, *Podozamites*, *Baiera*, etc., etc. They occupy the lower portion of the great artesian basin and are succeeded conformably by the Marine Cretaceous shales and sandstones. The rather scanty evidence at present available points to the fact that the sagging of the Mediterranean region was associated in its early stages with lacustrine conditions leading up to an invasion of the sea and marine sedimentation. These conditions on the coastal district ceased at the close of fresh water sedimentation, except in the Maryborough district, Queensland, where both fresh water and marine sedimentation took place

(2) The Upper coal measures of Tasmania may be correlated with the Gippsland measures of Jurassic age. *Tæniopteris daintreei* is wanting, but *Cladophebis denticulata* is abundant with *Thinnfeldia*, *Phyllotheca*, etc.

(3) In the Sydney area occurs the Hawkesbury series, made up of the Narrabeen, Hawkesbury, and Wiannamatta Stages. The Narrabeen shales succeed directly after the Upper coal measures (Permo-Carboniferous) with no break in sedimentation, and a mingling of the Glossopteris and Lower Mesozoic flora—*Glossopteris* and *Schizoneura*.

The Narrabeen, Hawkesbury, and Wiannamatta Stages have a well developed flora with *Thinnfeldia odontopteroides*, in several varieties, *Macrotænopteris*, *Alethopteris*, conifers, and *Phyllotheca*; there are distinct differences from the flora of the Ipswich Series, which are possibly due to more arid conditions. The Hawkesbury sandstones and Wiannamatta shales have a well-developed fish fauna—*Cleithrolepis*, *Gosfordia*, *Semionotus*, *Dictyopyge*, *Belonorhynchus*, etc., together with Labyrinthodonta, Platyceps, *Bothriceps*, *Mastodonsaurus* in part of Palæozoic and of Rhætic affinities. A depauperate foraminiferal horizon occurs in the Wiannamatta shales. It is usual to regard these beds of Triassic age in part, possibly slightly older than the Ipswich.

At Talbragar, New South Wales, beds with *Tæniopteris daintreei*, *Podozamites*, *Palissya*, *Alithopteris*, contain a distinctive fish fauna—*Leptolepis*, *Coccolepis*, *Aphnelepis*, etc., etc.

TERTIARY.—Terrestrial beds containing plant remains occur in the various States—the oldest series occur in the deep leads which may date back to late Eocene or early Miocene time. The vegetation of these deposits in Eastern Australia bears considerable resemblance to that of the modern "brushes" and afford evidence of more humid conditions.

In the late Tertiary and Pleistocene time, the inland plains supported a giant marsupial fauna, together with Ratite birds—*Diprotodon*, *Nototherium*, members of the Phascolomidæ, *Thylacoleo*, Macropodidæ, Monotremes, such as *Proechidna* and *Ornithorhynchus*; Birds—*Dromornis*, *Genyornis*, etc.; Reptilia—*Megalania*, *Crocodilus*, *Meiolania*, etc.

The giant members of this fauna have been found in all the states, but are most abundant in the great central plains of Queensland, New South Wales, and South Australia, where their remains are found in old lake basins, mud springs, and river beds. Their destruction was due to great diminution of rainfall which took place in late Pleistocene time.

8. Australian Cainozoic System.

By F. Chapman, A.L.S., Palæontologist to the National Museum, Melbourne.

The Australian Cainozoic system is remarkable for its great development of Miocene sediments. These are interposed between an important but locally developed Oligocene series below, and a more widely extended Pliocene series above.

In Victoria and South Australia, where the Cainozoic system is best developed, the beds can be subdivided into four principal series, for they are really more than stages, as time and further research may show. Local terms to denote these series have been suggested, as

shown in the following table, which also gives the probable equivalent to the corresponding European formations, according to the several authors quoted.

McCoy and Chapman.	Hall and Pritchard.	Tate and Dennant.
Pleistocene		
Upper Pliocene (Chapman)	Werrikooian (Pliocene)	Pleistocene (Tate) Pliocene (Dennant)
Lower Pliocene ..	Kalimnan (Miocene) ..	Miocene
Oligocene .. .	Balcombian (Eocene) ..	Eocene
	Janjukian (Eocene) .	? Oligocene (Tate) Eocene (Tate and Dennant)
Miocene .. .	Aldingan (Eocene in part)	Eocene in part

BALCOMBIAN SERIES.

General Characters.—Commencing with the Balcombian, these beds for the most part consist of sands and shelly marls, largely foraminiferal in places, and containing in the shallower deposits a very rich molluscan fauna, together with the remains of fishes, crustacea, especially ostracoda, polyzoa, echinoderms, gorgonids, corals, sponges, and the foraminifera aforesaid. Intercalated with the sandy clays and marls are beds of brown coal, which at Altona Bay and Newport, in Victoria, have been proved of considerable thickness. At one bore near Laverton (parish of Truganina, Section VII.), a bed of brown coal was struck at 347 feet, having a thickness of 74 feet. A bore at Morwell, in Gippsland, 1,000 feet deep, passed through 888 feet of brown coal. Although the actual age of the latter occurrence has not been proved, it is probably similar to the brown coal of the Port Phillip area.

Chief Fossils.—(B. = Balcombian; J. = Janjukian; K. = Kalimnan). *Lamna apiculata, Carcharodon, Megalodon, Aturia australis* (B.—K.), *Ancilla pseudaustralis* (B.—K.). *Voluta hamiltonensis. Fasciolaria lamellifera, Eburnopsis aulacessa, Cypraea ampullacea. C. eximia* (B. and J.), *Turbo hamiltonensis, Pecten murrayanus* (B.—K.). *Barbatia celleporacea* (B.—K.), *Crassatellites dennanti* (B. and J.). *Chama lamellifera* (B. and J.), *Magellania corioensis* (B. and J.), *Clypeaster gippslandicus* (B.—K.), *Echinolampas gambierensis* (B. and J.). *Placotrochus deltoideus* (B.—K.), *Platytrochus cuneus, Bactronella parvula. Amphistegina lessoni* (B.—K, most abundant in J.).

Localities.—The number of outcrops and exposures of the Balcombian series is seen to be very limited when the faunas have been carefully examined. The best-known and most accessible localities are Balcombe's Bay, near Mornington and Grice's Creek, near Frankston, both in Port Phillip. The gash made through superficial beds by the Muddy Creek, near Hamilton, reveals the lowest beds of the district at Clifton Bank, where they are brought

up by a slight monoclinal fold in the otherwise nearly horizontal strata. The beds here have their basement in blue clay containing a rich gasteropod fauna, the clay sometimes containing much glauconite and rolled fragments of polyzoa and cetacean remains. The presence of glauconite points to a fairly deep water origin for this bed. This dark clay bed passes rather rapidly into a brownish sandy marl with a rich molluscan fauna, gradually becoming more polyzoal in character towards the top, where, as recently found at 20 chains up stream in the Muddy Creek, it passes into the pink and yellow polyzoal limestone of true Janjukian character, and with foraminifera of a Burdigalian type.

The important bore at Sorrento, near the eastern head of Port Phillip, did not at its greatest depth, of 1,693 feet, reach the bottom of the Balcombian Series, which is here between 300 and 400 feet thick, so far as proved. On the other hand, bores at Altona Bay and Williamstown have proved the basement bed as a gritty quartz sand passing up into typical shell marls and blue clays with brown coal. The intercalated terrigenous and estuarine beds of the Balcombian, entitle it to be classed as a fluviomarine series in the areas just named, as much as those beds of similar age in Europe as in the Isle of Wight and Belgian Oligocene; whilst the North German Oligocene, being largely marine, may be classed with that of the lower beds at Muddy Creek and Sorrento. The Balcombian Series appears to be confined to the State of Victoria.

JANJUKIAN SERIES.

General Characters.—This is by far the most important group in the Australian Cainozoic system, and presents some remarkable and variable phases. On the terrestrial side, the leaf-beds with *Cinnamomum*, *Laurus*, and *Sterculia* probably come within this series, since stratigraphically the Maddingley leaf-beds seem to graduate into the limestones and marls of the Moorabool River area, finding their place in the Janjukian Series. So that in one area alone, the Geelong—Ballarat gulf and valley, we have fairly deep and clear water deposits, terrigenous shell-bearing beds formed closer inshore, and lacustrine accumulations.

The Corio Bay, Bairnsdale, and Fyansford fossiliferous deposits probably represent the basal part of the Miocene, to the middle of which period I have referred the Janjukian of Torquay and Batesford where, at the former place *Spirulirostra* occurs, and at the latter, Burdigalian foraminifera as *Lepidocyclina tournoueri* and *L. marginata*. In all probability, the general polyzoal facies properly belongs to the Middle Miocene.

At Bird Rock, Torquay, a magnificent cliff section is exposed, showing a vertical succession of 273 feet. The beds form a dome-shaped anticline, the centre of which is at Bird Rock. Forming the lowest of the series in this area, they can be traced either way along the shore where they pass up into a polyzoal and echinoid limestone with *Heteropora*, *Selenaria*, *Cellepora* (with large ramose and rod-like zoaria), and with *Echinocyamus* (*Scutellina*) *patella*.

In other localities enormous deposits of both hard and friable limestone are developed, which point to deposition in a rapidly subsiding marine basin at moderate depths, as witnessed by the presence of the larger shelled

foraminifera. These local foraminiferal deposits, as compared with those in coral reef areas at the present day, seem to indicate any depth between 20 and 60 fathoms, whilst the polyzoal rock must have accumulated at a depth averaging 100 fathoms, as borne out by recent dredgings in the Southern Ocean by the Federal Trawler *Endeavour*.

As was seen from the previous list of Balcombian fossils, many species range throughout the Cainozoic. Other species are peculiar to that series, but they are very rare. In the Janjukian Series, however, a great accession to the number of new forms takes place; although where the argillaceous conditions of the underlying Balcombian have continued, those older species persist into the newer strata. The limestone facies brings in quite a new population, for that condition of deposition was markedly absent from the Balcombian. The rule which governed the maximum development, generally in the Miocene, of certain fossil types in Europe, as *Clypeaster* for example, obtains here, since in one species, *C. gippslandicus*, the test is of medium-size in the Balcombian, gigantic in the Janjukian at Bairnsdale, and small again in the Kalimnan. Many other examples could be added, as those of *Linthia* and *Spondylus*.

Chief Fossils.—Cetacea—*Ziphius geelongensis, Parasqualodon wilkinsoni.* Fishes—*Carcharodon auriculatus, Carcharoides totuserratus.* Mollusca—*Spirulirostra curta* (only two other species known, and both from the Miocene, *viz.*, *S. bellardii* and *S. hœrnesi*), *Voluta macroptera, Volutilithes anticingulatus, Eburnopsis tesselatus, Morio wilsoni, Cypræa consobrina, C. platyrhyncha, Cerithium pritchardi, Turritella septifraga, Turbo etheridgei, Pleurotomaria tertiaria, Spondylus gæderopoides, Pecten eyrei, Limopsis insolita, Crassatellites oblonga.* Brachiopods—*Terebratula aldingæ, Acanthothyris squamosa.* Crustacea—*Lepas pritchardi.* Vermes—*Ditrupa cornea* var. *wormbetiensis, Serpula ouyenensis.* Echinoids—*Cidaris australiæ, Cassidulus australiæ, Brissopsis archeri, Eupatagus rotundus.* Corals—*Flabellum distinctum, Deltocyathus subviola, Stephanotrochus tatei, Graphularia senescens* (J. and K.). Sponges—*Ecionema newberyi, Plectroninia halli, Tretocalia pezica.* Foraminifera—*Gypsina howchini, Rotalia calcar, Amphistegina lessonii, Cycloclypeus pustulosus, Lepidocyclina tournoueri, L. marginata.*

Localities.—In Victoria—Spring Creek Series, Torquay (glauconitic and yellow marls, and polyzoal limestone); Waurn Ponds (polyzoal limestone and marls); Moorabool River and Batesford (*Lepidocyclina* and polyzoal limestone); Curlewis (polyzoal limestone and marls with calcareous sponges); Grange Burn, Hamilton (polyzoal limestone with *Lepidocyclina* and *Amphistegina*); Flinders (polyzoal limestone with calcareous sponges); Flemington, lower beds (fossiliferous ironstone); Keilor (foraminiferal limestone); Aire coastal series (marls and lignitic clays); Birregurra (grey and yellow marls); Bairnsdale (*Amphistegina* limestone and yellow fossiliferous marls); Corio Bay and Fyansford (yellow marls); bores in Mallee (white, polyzoal limestone and glauconitic marls).

In South Australia—Mount Gambier (white polyzoal limestone); Aldinga, lower beds (clays, glauconite marls, and limestones); banks of Murray River (polyzoal limestone); Murray desert.

Tasmania—Table Cape, near Wynyard, includes *Crassatellites* bed and overlying *Turritella* bed.

Probably the New South Wales leaf-beds (Dalton and Gunning) belong here. Their flora is largely that of Bacchus Marsh, Narracan, Berwick, Pitfield, Cobungra, Dargo, and Bogong.

KALIMNAN SERIES.

General Characters.—In the Sorrento bore the Janjukian marls pass insensibly upwards into the Kalimnan, without much lithological change; and by their containing a considerable amount of glauconite, denote that they were formed in moderately deep water. At Beaumaris, however, where these beds are well exposed in the cliff face, the rock is a yellow sandy marl, with numerous shells and sharks' teeth and occasional bands of fossils. The beds at Beaumaris are shallower in character, and evidence of current action is afforded by a nodule bed with numerous fish-teeth and rolled fossils at the base of the series. This nodule bed exactly corresponds in stratigraphical position with that at Muddy Creek and Grange Burn. The Kalimnan series at the latter localities consist of quite shallow water deposits, with *Mytilus, Natica, Nassa,* and *Barnea;* whilst the thick-shelled *Trigonia howitti* is further evidence in support of its shallow water origin. By the presence of *Scaldicetus* and other cetacean remains, the Lower Pliocene age of this series as stated originally by McCoy, is substantiated.

Chief Fossils.—Cetacea—*Scaldicetus macgeei. Physetodon baileyi.* Fishes—*Oxyrhina hastalis, Galeocerdo aduncus. Cestracion cainozoicus, Diodon formosus.* Mollusca—*Ancilla papillata, Voluta fulgetroides. V. masoni, Fusus gippslandicus, Natica cunninghamensis, Eglisia triplicata, Dentalium largicrescens, Pecten antiaustralia. Perna percrassa, Glycimeris halli, Trigonia margaritacea* var. *acuticostata, Sunetta gibberula, Mactra hamiltonensis.* Corals—*Trematotrochus clarkei, Notophyllia gracilis.*

Localities.—Upper beds. Muddy Creek; upper series at Shelford; lower Glenelg River; Beaumaris; Gippsland lakes; bores in Mallee, at 100 to 250 feet; Sorrento bore, at 585 to 741 feet (circ.); upper Murray cliffs; Adelaide; Haddon, Vict. (deep leads with plant remains).

WERRIKOOIAN SERIES.

In Upper Pliocene times the southern part of the continent had risen considerably, and corresponding denudation took place. The country must have supported a rich fauna, largely marsupial, of which we have evidence in *Phascolomys pliocenus,* of the Dunolly Gold Drift. The type locality of the Werrikooian is Limestone Creek, Glenelg River, where a rich marine molluscan fauna, with a large percentage of living species is found. The Upper beds of Moorabool Viaduct appear to belong here.

PLEISTOCENE.

The inland and coastal deposits such as cave floors, volcanic tuffs, and consolidated dunes afford evidence of many extinct and living marsupial genera, among the former being *Nototherium, Diprotodon, Procoptodon,* and *Palorchestes*; while the giant emu—*Genyornis*—occurs in the *Diprotodon* swamps of Lake Callabonna, South Australia, and also at Mount Gambier, and in Queensland. Remains of *Dromornis,* a struthious bird as large as the moa, occurs in the Pliocene of Queensland, New South Wales, and South

Australia. The volcanic tuffs of Tower Hill, Victoria. must be very late Pleistocene, for they overlie beds of marine shells identical in species with those now found living a short distance away on the sea-coast

The physiographical results of a study of the Cainozoics show that in Oligocene times the land suffered much oscillation, subsidence being sometimes in evidence, at others elevation. The climate was then warm-temperate to sub-tropical. With the Miocene was ushered in a great steady movement of subsidence, as shown by the great limestone series. with only occasional elevation, when the dynamical movements expressed themselves in volcanic outbursts, the older basalt filling up the valleys both inland and coastal, as at Dargo and Flinders respectively. The climate was probably warm-temperate. In the Lower Pliocene or Kalimnan times. elevation re-commenced, and gave rise to the shell-banks and shallow-water marls. The molluscan genera at this time indicate a climate similar to that now enjoyed. In Upper Pliocene and Pleistocene times, there is evidence for the belief that the climate became even colder than now, due probably to uplift, for estuarine sands found in the Mallee borings, perhaps 300 feet above sea level indicate a sub-temperate faunal character.

9. Igneous Rocks.

By T. W. Edgeworth David, C.M.G., D.Sc., F.R.S., and *Ernest W. Skeats, D.Sc., A.R.C.S., F.G.S., Professor of Geology in the University of Melbourne.*

PRE-CAMBRIAN.

The oldest known volcanic rocks in the Commonwealth are those of the Norseman and other regions of the great gold-bearing belts in the southern part of Western Australia. These are of the nature of amygdaloidal dolerites associated with contemporaneous tuff. Further north, as at Kalgoorlie and Coolgardie, these volcanic rocks have been altered into hornblende and chlorite schists, commonly spoken of as the " greenstone " schists, and it is in them that most of the payable gold-bearing belts occur. In the Pilbara district, rocks of this type belong to a lower division of the Algonkian group, known as the Warrawoona series. This is followed by a later Algonkian series—the Mosquito series—in which the Pre-Cambrian group terminates in that district. Plutonic rocks are also widely represented in the Pre-Cambrian group. For example, in Western Australia there are huge belts of granite passing into gneiss and traversed by veins of pegmatite. In places the granite intersects older diorite rocks. In other places, as at Kalgoorlie, serpentine occurs in the same group. The interesting observation has been made, at the Phillips River gold-field, on the south coast of Western Australia, that the local granite is of a very marked albite type, in fact it is almost devoid of any potash, but relatively high in soda. In the same region a quartz-ceratophyre has been identified, and the interesting question here suggests itself as to whether we may not have representatives of the third great division of igneous rocks—third in relation to the well recognised alkali and calcic types, namely the spilitic suite. From the Blyth Range, a myrmekite granite has been described, showing gridiron structure of quartz-felspar intergrowth, not original, and like that of similar granites, probably Archæan, in Sweden and Finland. It may be added that in the Phillips River

gold-field albite-pegmatite is of common occurrence, in which coarsely crystalline spodumene is associated with the albite. All these rocks are of Pre-Cambrian age.

In reference to its Pre-Cambrian igneous rocks, the State of South Australia is considered to be a petrographical province, the characteristic feature of which is the high percentage of titanium oxide, and, to a less degree, the abundance of soda. The rock which has given rise to these Pre-Cambrian igneous rocks may be termed the Houghton magma. From it have been produced ilmenite-diopside-diorite, ilmenite-diopside-syenite, ilmenite-sphene-actinolite-pegmatites, and ilmenite-felspar-quartz pegmatites with ilmenite quartz-veins.

The rocks of this Houghton magma are traversed by veins of "yatalite," a pegmatite formed of uralitic actinolite (after diopside) albite containing microcline, titaniferous magnetite, sphene and quartz. The actinolite is in large subidimorphic paramorphs after diopside. Gneissic normal granite pegmatite is associated with the "yatalite."

At Olary, a highly-titaniferous uranium-bearing mineral, davidite, occurs in a pegmatite vein, intruding Pre-Cambrian quartzite.

In addition there are present in this area epi-granites, diopside-diorites, granodiorites, hornblende-diorites approaching monzonite, mica-diorite, biotite-syenite, epi-syenite, and diopside-quartz-syenite with epidote.

The most typical rock of this series—the diopside-diorite—is interesting in view of its high content of soda (5·34 per cent), and titanium oxide (3·11 per cent.)

The magmatic name is tonalose.

In the Pre-Cambrian rocks of Tasmania, it is a singular fact that as far as is at present known, there is an entire absence of any kind of igneous rock whatsoever, with the single exception, perhaps, of the garnet-zoisite-amphibolite, which occurs just above Hamilton, on the left bank of the River Forth in the north-west of Tasmania. In Victoria, gneisses intruded by granitic rocks occur near the western border of the State, in the county Dundas, as well as in Gippsland, in north-eastern Victoria. At Broken Hill, on the south-western border of New South Wales, the augen-gneisses are Pre-Cambrian. In the Macdonnell Ranges, augen-gneisses traversed by very coarse pegmatites, with mica crystals in places up to 2 feet or more in diameter, are widely distributed. Large crystals of beryl, and occasionally tinstone, are associated with the pegmatite. These rocks are traversed by micropegmatites, granulitic pyroxene diorites, diorites, gabbros, dolerites, and amphibolites—all are probably Pre-Cambrian.

CAMBRIAN.

Perhaps the most extensive lava flows as yet recorded from the Commonwealth belong to this system. They are represented at Nullagine, in the Pilbara gold-field, where they occur a short distance above the basal gold-bearing and diamond-bearing conglomerates. They are partly acid rocks, and partly dolerites. In the Kimberley district, there are very large areas covered by what is called the great Antrim plateau basalt. At Mount Panton, this series of basic lavas and tuffs is capped by beds of somewhat phosphatic *Salterella* limestone. In Northern Territory there is a great series

of basalts and dacites associated with beds of volcanic tuff and agglomerate, the blocks of which are up to 4 feet in diameter. The thickness and full extent of this vast series and its petrological character is as yet almost wholly unknown, but there is little doubt that it is part of the great Antrim plateau group.

In the account of Cambrian rocks, reference has been made to the Heathcotian series of igneous rocks in Victoria. In the type locality altered basic submarine lavas or diabases predominate and are associated with altered submarine diabase tuffs, schalsteins, agglomerates, and minor diorite intrusions.

Interbedded with the diabases are black cherts, some containing radiolaria and at any rate in part derived by metasomatic alteration of diabase ash, while the diabase is in places silicified to jasper. At Heathcote, these rocks are invaded by micro granite, which may be genetically related to the diabase series. Near Heathcote, the diabase at its margin passes into "selwynite," a green alteration product containing a green chrome-bearing micaceous mineral, chromite, pyroxene, together with corundum. Corundum also occurs with chromite in the serpentine area, near Mount Wellington in North Gippsland, which is pre-Upper Ordovician, and may be Heathcotian in age. The quarries on Mount William, north of Lancefield, from which the aborigines manufactured tomahawks, occur in a similar diabase with interbedded black cherts and cherty shales, containing *protospongia* and radiolaria. Similar associations of diabase and cherts occur at Mount Major, near Dookie, and at Mount Stavely, while serpentinous diabase occurs at the Hummocks, north of Casterton, in Western Victoria. The whole assemblage of these Heathcotian series is strongly suggestive of a spilite suite, but chemical analyses of the rocks are not yet available. In Tasmania, probable equivalents of the Heathcotian volcanic series of Victoria are developed at North Dundas, Zeehan, the Leven gorge, etc., in the north-west and west of the island. These are known as the porphyroid series, and consist of dynamically altered quartz and felspar porphyries, amygdaloidal diabase (spilite ?), breccias tuffs, and tufaceous slates, together with intrusive syenites and granites.

ORDOVICIAN.

Igneous rocks possibly of this age have been described in South Australia from the Blinman mining field as melaphyres, olivine-diabase, granulitic-diabase, gabbro-diabase. These are perhaps related to the dykes of amphibolite with scapolitised felspar from the New Era mine, near Woodside. In Victoria, if the Heathcotian series is of Cambrian age, there are no known igneous rocks of Ordovician age. Basic agglomerates from Mount Arrowsmith, in New South Wales may also be Ordovician. At the Lyndhurst gold-field, near Mandurama, in New South Wales, there is an immense development of contemporaneous basic tuff in the Upper Ordovician black cherty graptolitic and radiolarian rocks. In the same state, at Cadia, near Orange, two sheets of andesite lava, 30 feet thick, interbedded in the upper Ordovician graptolite slates give evidence of contemporaneous volcanic activity. They are associated with a deposit of iron ore, estimated to contain about 40,000,000 tons of ore. At Forest Reefs, near Orange, this group of lavas and tuffs attains a great thickness.

SILURIAN.

In Victoria no definite evidence of contemporaneous igneous rocks of Silurian age has yet been forthcoming. It is possible that the alkali granites of Victoria, which as far as is known intrude the Ordovician and older rocks but not the Silurian series, may be of Silurian age.

DEVONIAN.

Lower Devonian.

In Victoria there occurs a wonderful development of igneous rocks, which have been referred to this period. It was a time of great earth movement in Victoria, when the older Palæozoic rocks were much folded, and it is probable that the intrusion and extrusion of igneous magma accompanied the movement of folding while the gold deposits appear also to be genetically related to the igneous intrusions and the gold quartz veins filled fissures which resulted from the folding movements or igneous invasions. Volcanic, dyke, and plutonic rocks are abundantly represented.

The Volcanic Rocks.—These include the following series:—

The Snowy River Porphyries.—These are acid lavas, mostly rhyolites and tuffs, in places over 2,000 feet in thickness. They were erupted from a chain of volcanoes, perhaps comparable to the Andes, and situated on a probable line of fissure trending nearly north and south through Eastern Victoria, near and along the Snowy River. Their worn-down stumps are now preserved in mountains like the Cobberas, Wombargo, Mount Hotham, etc., while the granite porphyries of Mount Taylor, Mount Alfred, etc., near Bairnsdale may represent the plugs of some of the volcanoes of this series. Probably of similar age are the rocks of Noyang, on the Tambo River, in Eastern Gippsland. These include intrusive as well as volcanic types, and consist of quartz porphyrites and quartz granophyrites. These rocks show a great preponderance of soda over potash and may be described as ceratophyres and quartz-ceratophyres

The Dacite, Quartz-porphyrite Series.—This series is developed in Central Victoria from sporadic centres. Fragmental rocks are scarce, except in the Lilydale district, and no volcanic necks have been located. The rocks consist of thousands of feet of rocks, mainly volcanic, but probably in part intrusive. The chief areas are Mount Macedon, the Dandenong Hills, Healesville, and Warburton, the Cerberean Range, the northern part of the Strathbogies, and near Whitfield, in Delatite. At Mount Macedon, the Dandenongs, Healesville, and Warburton, the rocks consist of hypersthene-biotite dacites, biotite dacites, and quartz-porphyrites. In the Strathbogies and in Delatite, garnet accompanies the quartz porphyrites, and here they are overlain by Lower Carboniferous sandstones. Probably the most complete sequence occurs near Lilydale, where fragmental rocks are abundant, and the earlier eruptions consisted of alkali dacites or toscanites, with about 7 per cent. of alkalies equally divided between potash and soda, quartz porphyrites followed, and the volcanic activity concluded with the eruption of normal hypersthene biotite dacites.

Hypabyssal Rocks.—Many of the granites and grano-diorites have marginal apophyses of quartz porphyry, pegmatites, etc., penetrating the invaded sediments. Of more economic importance are the altered types of dykes, some of which carry gold-quartz veins which have proved highly auriferous. Among these are the propylitised hornblende porphyrite of Woods Point and Gaffney's Creek, and the sericitic quartz-porphyry of the Diamond Creek mine, near Melbourne. The periodotites of Aberfeldy, the cupriferous hornblende amphibolites of the Thomson River, and the hornblende picrite of Sheep Station creek, near Omeo, may belong to this period.

Plutonic Rocks.—As stated in the stratigraphical part, the alkali granites, so far as is known, do not penetrate Silurian rocks, and may be of Silurian age, but there are petrographic grounds for associating them with the grano-diorites and adamellites, many of which are Post Silurian, and some of which, possibly all, are Pre-Lower Carboniferous.

The alkali granites, in which orthoclase predominates over plagioclase and potash generally over soda, include the masses of Mount Buffalo, Cape Woolamai, Gabo Island, and certain masses near Geelong, such as the You Yangs, the Dog Rocks, and an area near Ceres.

Certain diabases or epidiorites occur at Ceres and the Dog Rocks, which were formerly referred to the Heathcotian, but since they are probably genetically related to the alkali granites of these areas are now included with them in this place. Adamellites are known to occur near Violet Town and Nillahcootie, in north-eastern Victoria; at Trawool, Ingliston, north of Bacchus Marsh, and at Broadmeadows, near Melbourne.

The grano-diorite masses, with which many of the gold-fields appear to be genetically related are represented among other areas by the big mass south of Bendigo, including Harcourt, from which the rock is quarried for building stone, by an area near Pyalong, Bulla, Macedon, south of Mount Dandenong, and south of Warburton. In the three latter areas the grano-diorite is genetically related to the dacites, but is intrusive into them.

In New South Wales in the type district for Silurian rocks, that of Yass, dacitic tuffs containing contemporaneous corals and siliceous sponges are developed on a large scale. Individual beds aggregate several hundreds of feet in thickness. They are intruded by sills of porphyrite and granodiorite. Again, at Jenolan Caves, there is a considerable development of basic and intermediate tuffs with lavas, immediately underlying the *Pentamerus* limestone in which the caves are situated. Corals and crinoids are scattered through these tuffs. Most of these limestones of Jenolan, Yass, etc., represent old fringing coral reefs, and it is clear that these grew partly over banks of volcanic tuff and lava. The granites of the southern tableland of New South Wales, like that of Cooma, which are Post Ordovician and Pre-Devonian, probably belong here, as do the miarolitic granites of Parkes, which are Post Ordovician, and capped by Devonian rocks.

Middle Devonian.

In the Buchan series of Victoria there is a considerable development of felsite lavas called felsitic tuffs and breccias, which pass upwards into the Buchan limestone series. These vary from 750 up to 1,000 feet in thickness. Diabases and andesites also occur. In New South Wales, in radiolarian rocks of this age, there is a great thickness of tuff now proved to be of spilitic origin, like the pillow-lava of the British Isles. These Tamworth rocks also contain basic spilites. The whole series, including some marine beds of coral reef limestone, is estimated to be about 9,000 feet in thickness.

Upper Devonian.

In Victoria, at Mount Wellington, a great thickness, up to 2,000 feet, of acid lavas, rhyolites, and quartz-porphyrites, extend north-westward towards Mansfield. These lavas are proved to be probably Upper Devonian by the presence of the fossil *Lepidodendron australe*. Melaphyres, quite subordinate in importance to the rhyolites, are also met with in this series.

In New South Wales, rhyolites and basalts of this age occur at Yalwal.

Devonian Plutonic.

In Tasmania large masses of serpentine and granite were intruded, perhaps in Devonian time.

The serpentine is generally a peripheral mantle of serpentinised gabbroid and ultrabasic rocks surrounding the granite masses on the west coast. Occasionally between the granite and serpentine is an aureole of actinolitic rock. There is the clearest evidence that the ultra-basic rock consolidated before the granite.

This granite, unlike that of the porphyroid series, is uncrushed.

This granite is mostly tin-bearing. A remarkable feature about the serpentine is that it not only contains nickel and osmiridian, but, at Dundas, has tin ores associated with it.

CARBONIFEROUS.

In Victoria, the granodiorites and granodiorite-porphyrites of Mount William, in the Grampians, have recently been shown to be intrusions into the Grampians sandstones. In addition, sills, dykes, and possibly lava flows of quartz porphyry occur in the sandstone. These igneous rocks there are post Lower Carboniferous in age, and include the youngest series of plutonic rocks known in Victoria. Possibly the quartz-porphyries of Grangeburn, near Hamilton, and other localities in Western Victoria, may belong to the same period of intrusion.

In New South Wales there is a wonderful development of lavas and tuffs, all through this massive system which aggregates at least 20,000 feet in thickness. Its upper portion is formed very largely of rhyolite lavas and coarse acid tuffs, passing in places into hypersthene andesite. Immense sills of quartz-porphyry intersect this bedded series. Beds of arkose-like tuffs of great thickness, which at first sight appear to be granite but which are really acid tuffs, contribute considerably to the thickness of the system. It would appear that acid eruptions were in progress on a very grand scale in New South Wales during this period. Mount Spiriby, the highest point of Mount

Capoompeta in New England, is formed of rhyolite of this age. The andesites and rhyolites of the Drake gold-field are possibly Carboniferous, but may belong to the base of the Permo-Carboniferous system. In Queensland, lavas of the nature of amygdaloidal dolerites and agglomerates, in places containing metallic copper and carbonate of copper in the steam holes, are interstratified with sedimentary rocks at Mount Toussaint, in the Bowen coal-field.

Plutonic.

In New England, the immense belt of serpentine which stretches in a nearly continuous belt for fully 150 miles from Bingara to Nundle, is either of very late Devonian, or of Carboniferous age, and forms a mantle curving sympathetically with the huge intrusive batholiths and sills of granite of the New England tableland. On the eastern margins of the New England granites are large outlying masses of serpentine, on the Manning, Hastings, and Clarence Rivers. There is clear evidence here, as in Tasmania, that the granite has consolidated within a discontinuous ring of serpentine. In New England, there are three varieties of granite belonging perhaps to this period, the oldest being a bluish-grey biotite-hornblende-pyroxene granite-porphyry. This occurs perhaps as a huge sill: it was followed by widespread intrusions of sphene granite, full of dark, basic segregations. This in turn was intruded, probably in Permo-Carboniferous time, by an acid granite, containing up to 80 per cent. of SiO_2. The silica percentage in this group ranges from about 65 to 80. Most of the granites of Queensland may belong to this period.

PERMO-CARBONIFEROUS (PERMIAN).

Plutonic and Hypabyssal.

The intrusion of the acid granites, as already stated, had taken place in Permo-Carboniferous time. Possibly some of the Queensland tin-bearing granites belong to this age, as well as the diorite dykes which have intruded the Lower Permo-Carboniferous rocks of the Gympie gold-field, also in Queensland.

Volcanic.

In New South Wales, the great coal basin which separates the New England massif from the Bathurst-Monaro massif was the scene of eruptions of lavas and tuffs in Permo-Carboniferous time. At Harper's Hill, 7 miles west of West Maitland, coarse andesite tuffs and agglomerates are interstratified in the Lower Marine Series, and hyperstheneandesite, as well as natrolite basalt with datolite are intercalated in the upper part of this series below the horizon of the Greta coal measures.

An important group of alkaline eruptives occurs in the Cambewarra–Kiama districts, to the south of Sydney. This is partly contemporaneous with the top of the Upper Marine Series (shells of *Cleobis grandis* and *Chenomya* occurring abundantly in the basal tuffs, and partly with the Bulli coal measures. The series of lavas and tuffs, about 1,000 feet thick, shows the following sequence, the oldest being mentioned first:—orthoclase-basalts, or latites, the total alkalies ranging up to over 9 per cent., of which from 2 per cent. to nearly 5 per cent. are potash. These lavas range in composition

from shoshonose to monzonose, having points of resemblance to the rocks of the Yellowstone region, United States of America, the trachydolerites in part, and also being comparable with the "Ciminites" and "Vulsinites" of Italy. These earlier eruptions of alkaline, not very basic rocks, were associated with sills of monzonite, and possibly as the result of progressive differentiation) produced later, perhaps in Triassic time, peralkaline rocks like nepheline-syenite and tinguaite, as sills (the alkalies being 10 per cent. to 15 per cent.) on the one hand, and monchiquite dykes (alkalies under 4 per cent.) on the other. Both these types intrude the Permo-Carboniferous and Triassic rocks, and may be related to the Mittagong Post-Triassic Series, to be described later.

Still later basalts were erupted of a much less alkaline type. At Murrurundi, in New South Wales, there were extensive eruptions of basic tuff and lavas near the horizon probably of the Newcastle coal measures, the latter containing much chert formed by the alteration of powdered felspar and volcanic glass.

TRIASSIC.

Volcanic.—In New South Wales there is a considerable development of more or less fine volcanic tuff in the lower division of the Trias, known as the Narrabeen stage. These tuffs are distinctly basic in character, and like the lavas of the Permo-Carboniferous, contain metallic copper. Through redistribution in water the tuffs have passed into the characteristic chocolate shale, so well seen at Long Reef and Narrabeen, etc., to the north of Manly.

JURASSIC.

At Brisbane there is a considerable development of coarse rhyolite tuff, in the heart of the city itself, as at the Leichhardt quarries. Fossil trees completely carbonized are found embedded in the tuff. The tuffs are followed by basic lavas. It is as yet uncertain whether the Brisbane tuffs belong to the Trias or to the Jura system. To the south of Brisbane, in the direction of Mount Flinders and the Macpherson Ranges, trachytes are interbedded in the Jurassic rocks and are associated with *Tæniopteris daintreei.*

In Victoria, the Jurassic rocks were penetrated in a bore to a depth of over 3,000 feet, 60 miles easterly from Melbourne. The Jurassic strata, chiefly felspathic sandstones, are uniform in character over the state and have been shown to contain abundant fragments of undecomposed felspar, presumably of tufaceous origin. The source of all this tuff has not yet been discovered.

JURASSIC (?) (POSSIBLY TRIASSIC).

Tasmania.—Rocks of foyaitic magma are represented by the Port Cygnet series. These rocks are considered to be perhaps of Lower Mesozoic age.

At Regatta Point, Port Cygnet, the following occur :—Augite syenite, poor in quartz; nepheline syenite, essexite, jacupirangite facies of nepheline syenite, melanite-hauy-syenite porphyry, garnet-bearing mica solvsbergite, tinguaite, garnet tinguaite porphyry, nephelinite, etc. These rocks are all strongly intrusive into the Permo-Carboniferous series, but their relations to the Jurassic sedimentary rocks and to the diabase have not yet been clearly demonstrated.

Hypabyssal.—The close of Jurassic time was marked by one of the most wonderful manifestations of eruptive force of which we have evidence anywhere in the Commonwealth. The vast sills of dolerite, partly hünnediabase, that is an enstatite-augite diabase, partly konga-diabase, the latter containing normal pyroxene and granophyric intergrowths, probably may be referred here. These rocks have disrupted the Jurassic strata of Tasmania on a grand scale, and as individual sills are in some cases fully 500 feet in thickness and of immense lateral extent, portions of the Jurassic sandstones overlying them must have floated on this heavy magma like icebergs in a polar sea. As already suggested, these intrusions may have accompanied the breaking in of the big land bridges of Gondwana Land, which formerly joined Australia to India, South Africa, South America, and Antarctica.

Cretaceous.—No volcanic rocks of this age are known anywhere in the Commonwealth, with perhaps the single exception of the so-called Desert sandstones, like those of Port Mackay, in Queensland. It has been stated that part of these sandstones is built up of trachytic tuff.

CAINOZOIC.

A great variety of volcanic rocks belong to this era, especially in Eastern Australia and Tasmania. In lower Cainozoic time there were extensive outflows of basalts and eruptions of basic tuff. These are spoken of by the Victorian geologists as the older basalts. Probably the older basalts of New South Wales, and perhaps Queensland belong to this series. It is doubtful whether the series is represented either in South Australia, Tasmania, or Western Australia. In Victoria, where they have been most fully described they are developed at Melbourne itself at Royal Park, Essendon, Broadmeadows, and Keilor, where they occur underneath the lower Cainozoic fossiliferous sediments. They occur also near Geelong, as at Curlewis, at French Island and Phillip Island. At Cape Schanck, a bore penetrated them for over 800 feet, while at Flinders another bore was discontinued after passing through no less than 1,300 ft. of older basalt. They are widespread in south-east Gippsland, as at Buln Buln, Leongatha, Neerim, Mirboo, etc., while in north Gippsland they cap the plateau sometimes at elevations of 5,000 feet as at Mount Feathertop and Dargo high plains. Their chemical composition, so far as is known is normal, but occasionally crystals of anorthoclase are present. In texture, they range from tachylyte to coarse dolerites and their decomposition provides rich soils. In the fresh state they are quarried in places for road metal. Although in part apparently sub-marine, they do not, as far as is yet observed show affinities with the spilites. In New South Wales, there is a considerable development of older basalts overlying leaf beds first considered to be of Eocene age, though later there have been adduced strong reasons for considering that these leaf beds may be of somewhat newer age. They are typically developed in the New England district of New South Wales, where for the most part they consist of reddish decomposed amygdaloidal basic lavas, passing in places into dense columnar basalts. Frequently these New England lavas are capped by beds of laterite passing into bauxite and in places into pisolitic iron ore. These laterites mostly represent basalt tuffs.

MIDDLE CAINOZOIC.

This is a most remarkable group of volcanic rocks which, in eastern Australia and Tasmania, is distinctly of alkali characters. Rocks of this age and character extend at intervals from Casterton and Coleraine in western Victoria, through Mount Macedon and Omeo. In New South Wales they are met at Bowral, the Canobolas, Warrumbungle Mountains, Nandewar Ranges, the MacPherson Ranges. In Queensland they trend through Mount Flinders, the Fassifern districts. East Moreton, Wide Bay, the Glass House mountains. Mount Larcombe, Yeppoon to Clermont and Springsure. in North Queensland. The total distance over which they have been traced is over 1,200 miles.

Victoria.—In the Western District anorthoclase-aegirine-trachytes occur in a number of areas, including the neighbourhood of Carapook, Coleraine, Mount Koroite. Koolomert. and "the Giant Rock," at Wotong Vale. The hills of Adam and Eve, near Coleraine consist of anorthoclase olivine basalt traversed by a trachyte dyke. but at Mount Koroite and at Koolomert, the basic lavas appear to rest upon the trachytes.

The Mount Macedon alkali province in Central Victoria has been more closely studied than any similar area in Australia. Fragmental rocks are practically absent and the lava flows and intrusives were poured out over or intruded into a Palæozoic complex of Ordovician sediments, and Devonian dacites and grano-diorites. The sequence from below upwards appears to be as follows :—Anorthoclase aegirine trachyte, volcanic plugs or mamelons of solvsbergite, anorthoclase basalt and two new rock types, macedonite and woodendite, followed by anorthoclase-olivine trachyte, olivine anorthoclase trachyte and limburgite, the volcanic history of the area terminating with the pouring out of calcic newer basalts of probably Pleistocene age. The new types, macedonite and woodendite, present similarities to the orthoclase basalts, and closer resemblance to the mugearites. They contain alkali felspars associated with biotite and olivine, and have a high content of phosphorus and titanium.

Possibly the monchiquite dykes which come up the axes of the anticlines in the mining fields of Bendigo and Castlemaine, etc., may be genetically related to these alkali rocks.

In north-eastern Victoria alkali rocks probably of similar age to those of Mount Macedon, occur near Mansfield, Omeo, and Mount Leinster, in Benambra.

About 15 miles north-east from Mansfield, in the Tolmie highlands, Gallows Hill has recently been shown to consist of a volcanic hill with lava flows of nepheline phonolite. At Barwite, east of Mansfield, a similar nepheline phonolite appears to occur as a dyke, but its field relations have not yet been studied.

At Frenchman's Hill, just north of Omeo, a volcanic hill with central core of solvsbergite has on its flanks flows of anorthoclase trachyte, and a more or less radial system of dykes, including pegmatites, quartz veins, bostonites, diabase, trachytes, and nepheline phonolite. They have been described as of Palæozoic age, but are almost certainly Cainozoic. The phonolites of Omeo, Gallows Hill, and Barwite are the only ones as yet known in Victoria.

In Benambra at Mount Leinster, another volcanic hill includes solvsbergites anorthoclase trachytes, and interesting dyke rocks, some allied to variolite, and as in the case of Frenchman's Hill, this series has been regarded as of Palæozoic age, but is probably Cainozoic.

In the Mittagong-Bowral district of New South Wales, there is an important suite of eruptive alkaline rocks, all of which are intrusive into the Triassic sediments. They are chiefly developed at Gib Rock, and Mount Jellore respectively, 2,830 feet, and 2,734 feet high, both of which represent probably the denuded plugs of old volcanoes or dome eruptions, probably the latter. The sequence has been as follows: the oldest rocks being mentioned first:—

1. Alkaline rocks of intermediate composition—(*a*) Syenite, allied to bostonite, magmatic name boxanolose, containing fluorspar and occasional hydro-carbons, in addition to orthoclase, arfvedsonite aegirine, magnetite and ilmenite: (*b*) Ægirine-arfvedsonite-quartz trachytes. The total alkalies in the above two rocks range from 10 per cent. to 12 per cent.
2. Basic sub-alkaline rocks, with 46 per cent. SiO_2, total alkalies about 5 per cent. These rocks are essexites, with primary analcite.
3. Basic rocks—
   (*a*) Basalts and dolerites, SiO_2, 43 per cent., alkalies 3 per cent.
   (*b*) Picrites SiO_2, 40 per cent, alkalies 2 per cent.

Next on the western side of the Blue Mountains there lies a series of very perfect laccolites in the form of dome-shaped hills, like Mount Stormy and others, which are formed largely of nepheline, aegirine, a little anorthoclase, and a considerable amount of analcite. These have been described as syenitic tinguaites. Still further west, in the locality of the Canobolas, near Orange, there is a great development of alkaline lavas and tuffs, extending in a general northerly direction to the Warrumbungle Mountains, between Dubbo and Coonabarabran, and thence trending in a north by east direction into the Nandewar Ranges. From thence at intervals, the alkaline volcanic belt can be traced further into the McPherson Ranges dividing Queensland from New South Wales, through the Mount Flinders and Fassifern districts to East Moreton and Wide Bay: thence the belt trends northerly through the Glass House Mountains, near Maryborough. Still further north it has been identified at Mount Larcombe to the south of Rockhampton, as well as in the hills at Yeppoon, to the north-east of Rockhampton. Though this immense belt has been proved to extend in a north and south direction for a distance of about 800 miles, the belt is characterized physiographically by a number of dome-shaped or cylindrical hills, in many cases over 4,000 feet high, and very abrupt, marking the sites of old volcanic necks. In the Warrumbungle Mountains, at Wantialable Creek, the alkaline trachytic tuffs are interstratified with diatomaceous earths, the latter containing fossil leaves. These tuffs are formed of snow white, often perfect, crystals, of anorthoclase-felspar. The frequent association of diatomaceous earth with these volcanic rocks suggests a causal connexion. Meteoric waters, with their temperature raised through contact with heated volcanic rocks, and therefore capable of dissolving a relatively large amount of silica, together with the water of hot springs, probably favour the development locally of the diatoms. The

usual sequence seems to have been first, leucocratic trachytes (sometimes preceded by rhyolites) commencing with riebeckite arfvedsonite comendites passing upwards into pantellarites, followed by solvsbergites, phonolitic trachytes, and melanocratic trachytes. These are followed by alkaline andesites, and these in turn by basalts, either olivine basalts or olivine fayalite-melilite basalts. The sequence in most cases has been from acid to basic.

These volcanic rocks are associated with intrusive hypabyssal rocks of the nature of porphyrite, tonalite monzonite, soda andesite, etc. The whole group shows Eastern Australia to be an alkaline and titanium-rich petrographical province.

The melilite fayalite basalts and tuffs (alnoites), which break through the konga-diabase at One-Tree Point, Hobart, and the melilite-eudialite basalts of Shannon Tier, and the nepheline basanites of Table Cape, Tasmania, are perhaps to be grouped here. Their occurrence recalls that of the alnoites which have intruded the diabase of South Africa. Perhaps to the closing phases of these alkaline eruptions belong the leucite lavas of Byrock, Capitan, Harden, and Lake Cudjellico, the essexites of Prospect, near Parramatta, the nepheline basalts of Capertee, Mount Royal, etc., in New South Wales, the nepheline basalts of Mount Beardmore, and the leucite-basalts of the Normanby Reefs in the Cooktown district in Queensland.

It is possible, however, that the above lavas are Newer Cainozoic.

NEWER CAINOZOIC TO RECENT NEWER BASALTS.

These rocks form physiographically very extensive plains, stretching from Mount Gambier in South Australia, through the western district of Victoria to Melbourne, in several places, as in the Loddon Valley, running long distances to the north of the main divide. These basalt plains are diversified by hundreds of small volcanic cones or "puys," in various stages of preservation or dissection, and probably the most recent cone is the compound one of Tower Hill, west of Warrnambool. Much of the lava forming the plains probably proceeded from fissures now concealed beneath the lava flows. In places shallow broad depressions of the lava surface have led to the formation of extensive lakes over these plains, while in places the present streams have trenched deep and sometimes wide valleys through them. The rocks are mainly normal calcic olivine basalts, but in places, as at Ballarat and Melbourne, occasionally contain a few crystals of anorthoclase, while analcite has been recorded from a coarse type of olivine-augite dolerite or essexite, occurring as boulders in the tuffs at the base of the volcanic series at Lake Bullenmerri, near Camperdown. The eruptions appear to be connected with extensive movements of subsidence and of faulting which affected Victoria at intervals from post Pliocene to recent times, and in some places the sequence of rocks was first tuffs, then lava flows, while the later volcanic cones, many with perfectly preserved craters, consist mainly of scoria and tuffs. The texture of the basalts varies from coarse dolerites, through finer varieties to the glassy form—tachylyte, such as is found at the Lal Lal Falls and the Merri Creek, near Melbourne. The rock is extensively quarried as a building stone, and constitutes the road metal of Melbourne

and many other localities. These newer basalts in Victoria frequently sealed up old river valleys, the deep leads which contained rich deposits of gold-bearing sands and gravels, as at Ballarat, Ararat, and the Loddon Valley.

In South Australia, Mount Gambier, Mount Reid, Mount Leach, etc., represent recent olivine basalt cones and craters. The basalt flows of Kangaroo Island probably belong here, as may those of Bunbury, in the south-eastern part of Western Australia. Probably most of the basalts of Northern Tasmania, including at Sheffield the tachylytic variety, belong here. In New South Wales, the newer basalts are widely distributed and in places form the cappings of deep leads. Basalts are abundant in the New England district, and on the border of Queensland occur at Tweed Heads. In Queensland, there are some nearly perfect craters, enclosing crater lakes, preserved on the flanks of the Bellenden-Ker Ranges. From their perfect state of preservation, it is probable that they too belong to a late stage of newer basalt series.

In Papua, basalts and agglomerates, some 3,000 feet in thickness, overlie a peneplain cut out of the highly-folded Pliocene Port Moresby beds. Mount Victory, in British Papua, over 6,000 feet high, is the only lava producing volcano at present known within the territory of the Commonwealth. This has not yet been explored.

10. Metamorphic Rocks.

By Prof. T. W. Edgeworth David, C.M.G., D.Sc., F.R.S., and Prof. Ernest W. Skeats, D.Sc., A.R.C.S., F.G.S.

Contact Metamorphism.—Apart from the normal developments of hornfels, andalusite mica schist, cordierite mica rocks, etc., where granitic rocks have invaded shales, rocks such as garnet-rock, wollastonite rock, epidote rock occur at the contact, chiefly between acid eruptives and limestones, and ophicalcites where the latter have been intruded by ultrabasic pyroxene rocks belonging to the peridotites or picrites. Contact metamorphic rocks of special interest occur at the Mount Bischoff tin mine in the north-west part of Tasmania. There a quartz-porphyry, which has broken through slaty rocks, probably of Ordovician age, has had the whole of its felspar converted by pneumatolysis into fibrous radial topaz (pycnite). The rock at the same time has been tourmalinised, with a development in places in a massive form of tourmaline veins and irregular lumps, of the dark-green ferriferous variety zeuxite. An interesting type of contact alteration is produced by the intrusion of granodiorite into dacite, near Selby, in the Dandenong hills, at Warburton, and Mount Macedon, in Victoria. The dacite becomes slightly schistose. Hypersthene is converted into secondary biotite, ilmenite reacting with felspar forms fringes of secondary biotite, the ground mass is re-crystallized on a larger scale and some secondary blue tourmaline is developed. Near Selby, local development of crystalline biotite gneisses from the hypersthene dacite occur near the granodiorite contact. In this case it is possible that dynamic metamorphism reinforced the contact effects. Adinoles have been recorded amongst the cherts in the Heathcotian series of Victoria, but the analysis suggests that they do not vary much from the normal cherts in

spite of the fact that their association with albite-diabase flows, schalsteins, tuffs, and radiolarian rocks suggests a local development of the spilite suite, with which adinoles are often associated.

Dynamic Metamorphism.—Under this heading may be included the phyllites and the crystalline schists.

Phyllites.—Argillaceous sediments altered to phyllites occur in the districts of Kosciusko, Cooma, and Cobar, in New South Wales, and in Victoria are represented near Yackandandah, and in several other localities in the metamorphic belt of north-eastern Victoria, and in Dundas in western Victoria. The precise age of many of these rocks is undetermined, but some have been referred to the Pre-Cambrian Series.

Crystalline Schists.—Very little work has as yet been done in the way of classifying these rocks on the principles of Grubenmann. There is here an enormous field for research, more than a third of Australia, including large parts of Western and South Australia, western New South Wales, and areas in western and eastern Victoria, and a large portion of Tasmania being formed of these rocks. Rocks of Grubenmann's upper, middle, and lower (deep) zone are well represented. Typical of the upper zones are chloritoid schist, talc schist, chlorite schist, talc schist, the schistose amphibolites and serpentinized areas of the Broken Hill area in New South Wales, the epidiorite, the glaucophane rock and glaucophane-epidote rock, albite-chlorite-sillimanite schist of Leahy's Creek, in the D'Aguilar Range area, north of Brisbane, in Queensland; the sericitic quartzites, magnetitic quartzite, conglomerates, talcose slates, and epi-magnetite slates of Northern Territory, the Algonkian (?) quartz-schists of Tasmania, and crushed quartzite conglomerates of Goat Island, near Ulverstone, in Tasmania, muscovite schists, quartz schists, chlorite schists of the Mount Lofty to Murray Bridge region to the east of Adelaide, chlorite, amphibolite graphite schists, siliceous mylonites (ribbon jasper), and crush conglomerates of felspar porphyry of Kalgoorlie, in Western Australia.

Amongst rocks which characterize the middle zone are the staurolite gneisses, staurolite mica schists, zoisite schists, and tremolite schists of the Broken Hill area, the tremolite schists, actinolite schists, muscovite-biotite schists, andalusite schists, and "paringite"* schists of the Mount Lofty to Murray Bridge area, the muscovite and biotite schists of western and north-eastern Victoria; the muscovite-biotite schists, garnet-zoisite amphibolite rock of Forth River, Tasmania; cyanite-rutile granulite, epidote-actinolite topaz schist, anthophyllite schist from D'Aguilar Range area, Queensland.

Possibly to this middle group may be referred the remarkable sapphire schists of Mount Painter. At Mount Painter, 300 miles north-west of Broken Hill, there occurs a rock formed of corundum, often as sapphire, cordierite sillimanite, pleonaste, magnetite, and abundant apatite, monazite and tourmaline.

These schists are traversed by an immense lode containing radio-active minerals such as autunite, torbernite, monazite radio-active fluorspar, etc. To the lowest or middle zone may belong the epidote-cordierite-chlorite

* A moderately coarse friable silvery muscovite-biotite schist with very wavy lamination, and with very prominent "knots" or "eyes" of impure andalusite, which may be upwards of an inch in diameter.

schist, the cyanite-rutile granulite, the granulitic mica schist, and the muscovite granulite of the D'Aguilar Range area, and the muscovite-sillimanite chiastolite schist, with andalusite schist, of the Mount Lofty to Murray Bridge area.

The following types, perhaps belonging to the deepest zone, have been identified in Australia :—Kata-biotite orthoclase gneisses, sillimanite gneiss, garnet-sillimanite schist, cordierite-granulite, scapolite-gneiss and plagioclase pyroxene rocks, from the Broken Hill area, and scapolite-amphibolite rocks and amphibolites, with sphene and vesuvianites from the Mount Lofty Ranges, to east of Mount Lofty. The sillimanite schists and gneisses near Tallangatta, and elsewhere in north-eastern Victoria, may belong here.

The following metamorphic rocks seem of special interest :—

(1) The mylonized granophyric quartz-dolerites of Western Australia, passing at one end of the series by introduction of silica and formation of haematite into red ribbon jaspers and haematite schists, and at the other end, as the result of the introduction of plutonic carbon, as methane, etc., passing into graphite schists, as at the Great Boulder mine at Boulder, adjacent to Kalgoorlie, where methane is still being given off in the deep levels of the mine, at 2,000 feet below the surface. The ribbon jaspers and haematite schists can be traced for fully a thousand miles, at intervals from the extreme south to the extreme north of Western Australia. Where quartz reefs traverse these metamorphosed mylonized rocks they are generally gold-bearing.

(2) The remarkable belt of sapphire schists adjacent to the great radium-bearing lode of Mount Painter.

(3) The glaucophane schists of Mount Mee in the D'Aguilar Range area of Queensland, to the north of Brisbane.

(4) The important belt of the Broken Hill area, with its sillimanite gneiss, scapolite gneiss, pyroxene-amphibole rocks, etc., characteristic of Grubenmann's deepest zone.

(5) The wonderful chiastolite belt of Bimbowrie to the west of Broken Hill. These chiastolites, often 5 to 6 inches in length, and over an inch in diameter, have in some cases suffered paramorphism, and pass into aggregates of pinite, with occasional grains of corundum. The important "paringite" belt of Mount Lofty may also belong to this horizon.

11. Papua.

New Guinea, 1,500 miles long, with an extreme width of 380 miles, and an area of 306,000 square miles, is one of the biggest islands in the world.

Apart from Polar regions, perhaps, no portion of the world has been so little explored, and yet it probably yields to no other part in scientific interest. If it were possible to travel from the coast inland in a bee line for from 30 to 100 miles,* one could pass from the dense, steaming, tropical atmosphere of the lowlands, with its rattan-tangled jungles and bright scarlet creepers to the bracing air of the open forest glades, where the pink rhododendron forms a

* So dense is the growth of the jungle that it took the Goodenough-Rawling expedition no less than five weeks to travel inland five miles.

PLATE VIII.

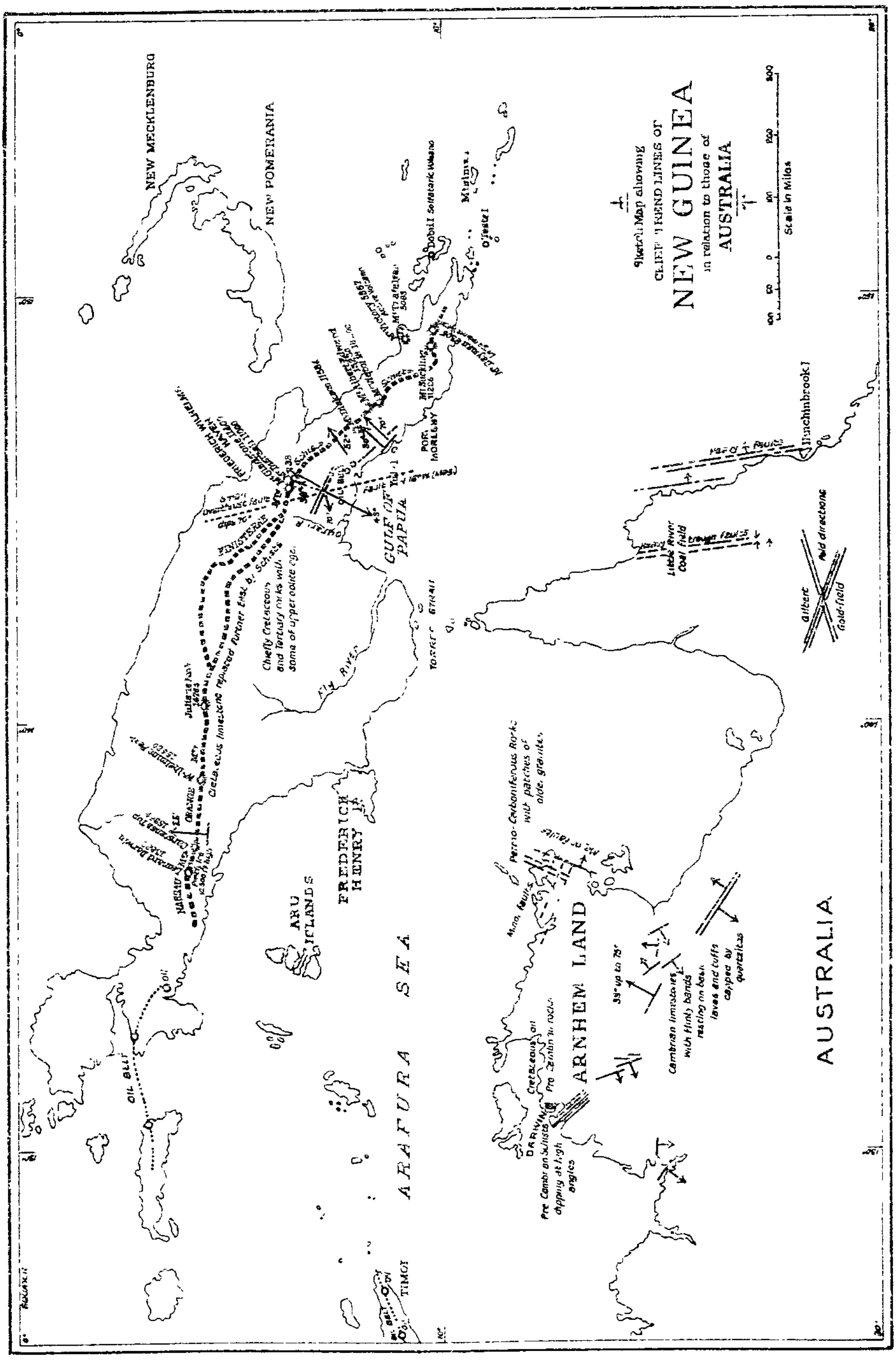
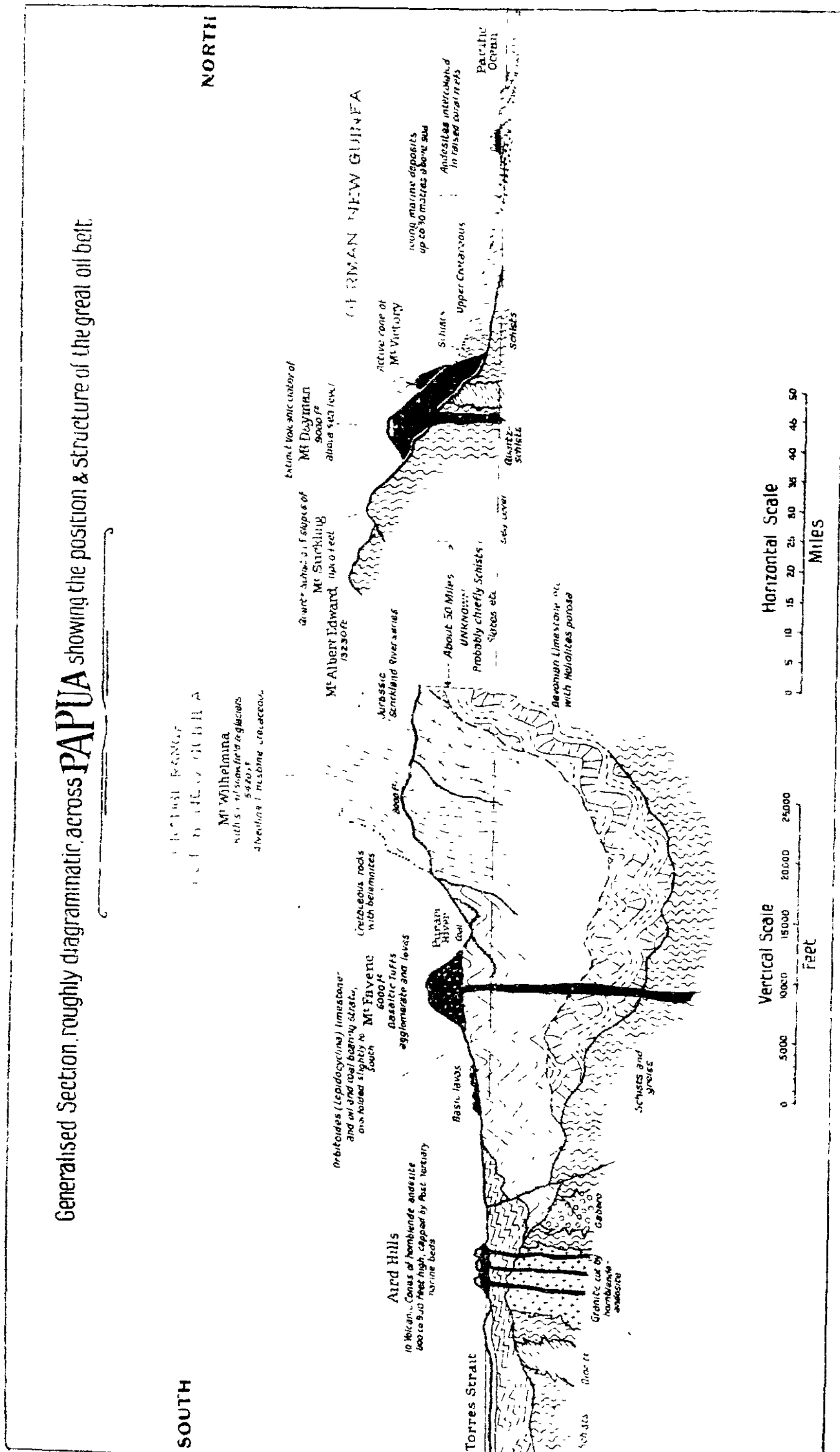
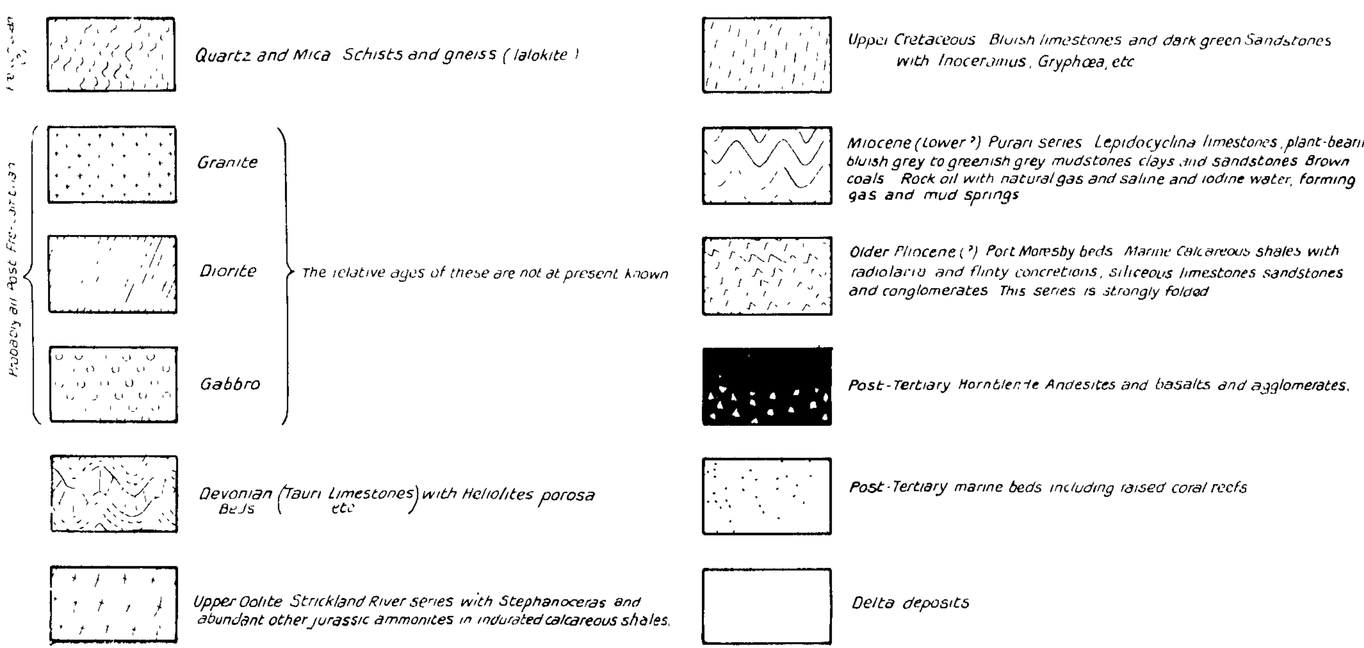

Sketch Map showing
CHIEF TREND LINES OF
NEW GUINEA
in relation to those of
AUSTRALIA
Scale in Miles
NEW MECKLENBURG
NEW POMERANIA
GULF OF PAPUA
FINISTERRE
FLY RIVER
TORRES STRAIT
Chiefly Cretaceous and Tertiary rocks with some of upper oolite age
FREDERICK HENRY I.
ARU ISLANDS
ARAFURA SEA
OIL BELT
TIMOR
ARNHEM LAND
DARWIN
Pre Cambrian Schists dipping at high angles
Permo-Carboniferous Rocks with patches of older granites
Cambrian limestones with flinty bands resting on basic lavas and tuffs capped by quartzites
39° up to 75°
Little River Coal field
Albert Gold-field
Hinchinbrook I.
AUSTRALIA

PLATE IX.



Generalised Section, roughly diagrammatic, across PAPUA showing the position & structure of the great oil belt.

Index to Geological section of Papua



glowing fringe to the sombre mantle of pine and cypress which clothes the higher slopes. In British New Guinea, one may climb above the tree line to the Alpine grasses and flowers, and extinct glacial lakes of the great horst, where, even in midsummer, in early morning the grass and wild strawberries are white with frost, and all the shallow pools are crusted with ice. Higher still, bare peaks and pinnacles of dark schists pierce the clouds. Among their sharp serrated ridges and spurs the mountain torrents gather for their leap down steep ravines into the valleys far below. In Dutch New Guinea there are even perennial snows and glaciers in the Nassau and Orange Ranges, the latter reached in 1905 by Dr. Lorentz and his comrades.

The association in New Guinea of *Dendrolagus* and *Prœchidna* with the cloven-footed *Sus papuensis*, of *eucalyptus* and *casuarina* with the oak and rhododendron, are typical of that commingling of Indo-Malayan with Australian forms which makes New Guinea so happy a hunting ground for the botanist and zoologist. The aborigines, including the pygmies, with their primitive pile dwellings recall the lake dwellers of Europe, and present a most fascinating study for the anthropologist. Geologically as well as biologically New Guinea shows a commingling of Oriental with Australian elements.

Papua tectonically and palæontologically is an oriental element in the Australian region. It is part of the Himalayan-Burmese arc, prolonged through the Malay Peninsula, Sumatra, Java, and Timor.* It is specially linked up with the Burmese arc by the great oil belt lately found in Dutch New Guinea and British New Guinea. The limestones, so rich in *Orbitoides* (*Lepidocyclina*), recently discovered at Bootless Inlet, to the east of Port Moresby, are probably of Lower Miocene age, and appear to be close to the horizon of the Papuan oil belt. Its trend lines are continuous with those of the Malay Peninsula; and the direction and age of the folding, extending as it does into late Pliocene time, agree with those of the Burmese arc. In Australia, on the other hand, the latest strong orogenic movements, though prolonged in places into the Lower Permo-Carboniferous age, ceased for the most part in Carboniferous time. The trend of the main folds in New Guinea is in a west to east direction from the Charles Louis Range and Mount Leonard Darwin to the north-west end of the Finisterre Mountains. Thence the trend is nearly south-east, to near Mount Suckling, and thence to the Louisiade Archipelago east-south-east. A probable virgation of the main trend line is indicated by the great promontory of New Guinea, opposite New Pomerania, and by the long axis of that island

This strongly marked Burmese trend line is crossed by minor trend lines, subordinate folds and faults, more or less meridional, coming from Australia. These manifest themselves where the strong faults at the north-east end of Arnhem Land, running north by east, pass over into Frederick Henry Island, and also in the faults and small cross folds inland from the Gulf of Papua, in the neighbourhood of Port Moresby, and at Ware (Teste) Island, etc. On the Purari River there is evidence of minor overthrust faults with the overthrusting coming from west-south-west, as well as of the dominant north-west to south-east trend lines. On the whole, evidence up to the present suggests that the overfolding of New Guinea has been directed in the western half of

* The Timor trend line marks a N.E trend of the arc of new folded rocks bending away from its E.W. direction owing to the resistance set up by the great crystalline massif of Darwin and Arnhem Land, whose trend lines are directed to the N W or N.

the island from north to south, and in the eastern half, from north-east to south-west. In other words, New Guinea has been overfolded towards Australia.

The physiographic geology of New Guinea is unique. The backbone of New Guinea appears to be a horst mostly part of an old peneplain. This, from the south-east extremity of the island as far as to, and including, the Finisterre mountains is formed of crystalline schists and gneisses, probably Pre-Cambrian. At some spot, not yet explored, to west of the Finisterre mountains, and between them and Mount Wilhelmina Peak (15,420 feet), the divide is formed of Cretaceous *Alveolina* limestone. Further west, and south of Carstensz Top and Mount Leonard Darwin, Rawlings has described perhaps the most stupendous precipice known anywhere in the world, recalling the fractures of the lunar Apennines. He estimates its height at 10,500 feet, and considers that it is of tectonic origin. The precipice faces the south, and is no doubt evidence of a powerful inthrow in that direction. Possibly folding has contributed to this gigantic displacement, but to what extent, if at all, is not at present known, but from the evidence further east, on the Purari River, it may be inferred that the disturbance is in part, at any rate, due to folding.

On the northern slopes of Mount Suckling, at an altitude of 8,000 feet, an immense sheer cliff of quartz schist faces the north-east, and perhaps indicates a downthrow in that direction.

The nearly uniform height of the main Divide in the eastern part of the island, rising to from 11,000 to 13,000 feet above sea level, as well as the profile of the ranges, strongly suggests an old peneplain, which has been block-faulted and subsequently deeply dissected.

This peneplain has been carved partly out of Pre-Cambrian schists, partly out of Devonian, Upper Oolitic and Cretaceous rocks. As the Cretaceous transgression probably covered nearly the whole of the island, the peneplain composed partly of steeply dipping Cretaceous rocks must obviously be Post Cretaceous, though it is possible that the schist portion of the peneplain belongs to a Pre-Cretaceous peneplain re-discovered in Post Cretaceous time.

The coastal region and foot hills inland from the Gulf of Papua for a distance of 50 or 60 miles belongs to a second peneplain, carved out of Miocene to Pliocene estuarine and marine strata. The Miocene transgression was far less extensive than the Cretaceous, and the Pliocene less extensive than the Miocene. Even the Pliocene beds (Port Moresby bed) have been intensely folded, and these folded rocks have subsequently been reduced to the level of this second peneplain. This lower peneplain has been covered in Post Pliocene time partly with basaltic and andesitic tuffs and lavas to a depth of from 1,000 to 2,000 feet. A recent transgression has carried horizontally bedded coral reefs over the top of some of the Post Tertiary volcanic rocks, while in other places the coral rock rests directly on the Pliocene beds. These recent coral-reef limestones are now found up to altitudes of 1,000 feet, and exceptionally up to 2,000 feet, above sea level, on the south-east side of Papua. This proves that a negative movement of the strand line of the order of 1,000 to 2,000 feet took place in south-eastern New Guinea in recent geological time.

This recent emergence of the land has been the cause of modern canyon cutting like that of the canyon of the Laloki River, near Port Moresby.

Another alternative explanation of the physiographic geology is that the whole country from sea to sea, up to the top of the divide, belongs to one and the same peneplain, which has been heavily block-faulted in late Pliocene or even Pleistocene time.

Against this interpretation may be adduced the facts—(1) that so far no rocks newer than Cretaceous have been encountered in the region of the divide or anywhere above a level of about 4.000 feet. (2) The main divide portion of the peneplain is so deeply dissected that Post Pliocene time alone may not have sufficed for the work.

Probably connected with the lines of block faulting was the manifestation of volcanic energy, which produced basaltic lavas and tuffs like those of Mount Favenc, and built the volcanic cones and craters respectively of Mount Dayman, 9.305 feet, and of the active volcano, Mount Victory, about 6.000 feet high—the only lava producing volcano within the Commonwealth—as well as the cones of the solfataric volcanoes of the D'Entrecasteaux Group such as that of Dobu, etc. The sharp shocks of earthquake occasionally experienced in British Papua obviously have relation to crustal readjustments connected with the volcanic zones, or movements along fault planes. That New Guinea was not exempt from the great Ice Age of Pleistocene and in part Recent time, which affected south-eastern Australia at Mount Kosciusko, the highlands of Tasmania, and the cordilleras of New Zealand, Patagonia, and Tierra del Fuego, is proved by the evidences of past glacial action observed by Dr. Lorentz, below Wilhelmina Peak, extending downwards to at least 13.200 feet, where glacial lakes with striated rock surfaces were observed. The numerous small lakes and tarns on Mount Albert Edward and Mount Victoria, both of which are over 13.000 feet high, make it nearly certain that these peaks were also at one time glaciated.

One of the latest phases in the evolution of the Papuan landscape has been the reclamation of shallow portions of the continental shelf by river deltas. This is specially to be noticed in the Gulf of Papua, where vast amounts of silt are washed into the sea annually by the Fly, Kikori, and other rivers.

The sequence and character of the formations represented are shown on the diagrammatic section. This section shows that there is a large area in Central Papua as yet mostly unexplored.*

Little is as yet known of the crystalline schists and gneisses, which form the backbone of most of the island, beyond the fact that quartz mica-schists, talc schists, and chlorite schists are represented. These are intruded in places by granites, diorites, and gabbros. Gold-bearing quartz-reefs are associated with these intrusive rocks, and copper deposits are developed

* Not only is the geological structure unknown, but even the zoology has been only very partially studied, as is evident from the following facts:—It has been recorded by Mr. C. G. W. Monckton that near the lakes of Mount Albert Edward he observed at over 12,000 feet above sea level, footprints of an unknown animal with cloven hoof, the footprints measuring about four inches by four and a half inches—the imprints were quite unlike those of the *Sus papuensis*. He adds that the description given by the natives of the creature that leaves these footprints suggests an animal like the hog-deer (*Sus babirussa*) of the Indian islands.

in connexion with the gabbros. So far the existence of Devonian rock has been proved only on the Tauri river, to the east of Purari river, and 29 miles from the coast. The Upper Oolites are represented by calcareous shales, 75 miles up the Strickland river, above its confluence with the Fly river. These contain *Stephanoceras blagdeni*. *S. lamellosum*, and an ammonite, of *A. lingulatus*, from the White Jura, together with an *Aucella* or *Inoceramus*.

The Cretaceous strata, mostly dark-green calcareous and glauconitic (?) sandstones and limestones, contain *Alveolina*. *Orbitolites* (*Flosculinella* Schu.) *Inoceramus*. *Gryphæa*, *Modiola*, *Aviculopecten*, *Protocardium*. *Cidaris*. *Belemnites*, etc.

The oil belt, without doubt a continuation of the Burmese oil belt, is part of a vast delta or estuarine deposit, consisting of freshwater beds alternating with marine limestones. The limestone of Bootless Inlet to the east of Port Moresby, formed chiefly of beautiful shells of *Orbitoides* (*Lepidocyclina*), probably belongs to the oil belt.

In places the Miocene limestones are formed chiefly of *Globigerina*, like the well-known *Globigerina* limestone of Noumea. Some of the friable sandstones are extremely rich in mollusca, of which 32 genera have been identified by Mr. W. S. Dun and Mr. C. Hedley, the latter being of the opinion that the greater proportion are species new to science.

Seams of brown coal occur at intervals, the thickest seam so far proved being 2 feet 9 inches. The brown coals from British Papua have approximately the following composition :—

Hygroscopic moisture	13 per cent. to	21 per cent.
Volatile hydrocarbon	37	42 ..
Fixed carbon	34	41 ..
Ash	3 .. ,,	9 ..
Sulphur	3 .. ,,	2 ..

The whole series has been strongly folded along E.S.E. to W.N.W. lines or north-west to south-east lines, crossed by north and south lines.

The oil is associated with anticlinal arches in a bluish-grey mudstone and clayey sandstone, in which it occurs as yellowish-brown globules. This is found in the neighbourhood of the Vailala and Purari Rivers, a short distance above their mouths, to the west of Port Moresby.

Crude petroleum oil collected by Mr. J. E. Carne, F.G.S., was analysed by Mr. J. C. H. Mingaye, F.C.S., with the following results :—

	P in 100 parts.	Sp Gr.
Petroleum spirit below 150° C.	Nil	..
Burning oils distilled below 300° C.	20·8	0·9283
Intermediate and lubricating oils with solid hydrocarbons	74·2	0·9733
Coke	5·0	..
	100	

That the petroleum spirit had evaporated from these superficial strata as the result of weathering is proved by the fact that light volatile oils have lately been obtained in a bore 300 feet deep on the west side of the Vailala River near its mouth.

The water associated with the rock oil was found to have the following composition:—

	Grains per gallon.	P. in 100 parts.
Total solid matter (dried at 220° F.) ..	842·60	12·038
Chlorine as chlorides	424·62	6·066
Sulphur trioxide as sulphates	Nil	Nil

The solid matter was chiefly sodium chloride with some sodium carbonate, magnesium carbonates, silica, etc. Calcium carbonate, 9·64 grains per gallon; magnesium carbonate, 1·60 grains per gallon; silica, 1·80 grains per gallon. A strong reaction was obtained for the presence of iodine and boric acid in the water. It is thought possible that this iodine water may later prove of value for the extraction of iodine from it, like that of Golnosk Soerabaia Island, Java.

Port Moresby Beds.—These strata, radiolarian in places, and marked by large onion-like concretions of chalcedony up to several feet in diameter, are as strongly folded, mostly overfolded, as are the lower Cambrian rocks of the Mount Lofty Range, near Adelaide, and yet these Port Moresby beds are probably not older than Pliocene. Thus the orogenic movements which have produced the cordillera of Papua must have been acute down to as late in geological time as the Pliocene period.

Post Pliocene.—These are largely composed of volcanic rocks. The volcanic rocks of this age in British Papua have as yet been very little studied. They are known to consist of hornblende andesites and basalts. In the island of Misima (St. Aigan) are thin flows of trachyte. The Papuan lavas appear to belong to two volcanic zones as shown on the section, in which the Aird Hills (about 200 miles north-west from Port Moresby) belong to the southern zone facing Torres Strait and the Arafura Sea, and the other parallel and adjacent to the northern coast of British Papua. The great extinct crater of the unexplored volcano, Dayman, 9,305 feet high, belongs to the northern belt, as does Mount Victory, 6,000 feet high, which still produces lava.

That incandescent lava is present in the crater of Mount Victory is proved by the fact that Mr. A. Gibb Maitland observed on two occasions that the steam clouds hovering over that mountain were seen, after nightfall, to be brilliantly illuminated.

Mount Victory, as far as is known, is the only lava-producing volcano in the territory of the Commonwealth. It has never been geologically examined. The small island of Dobu (Goulvain) in the D'Entrecasteaux Group is a volcanic cone, from which steam is still emitted. This is also situated on the northern volcanic belt. In regard to the broad tectonic features of Papua it may be suggested, very tentatively, that the mainland of Australia has functioned as a "forland massif," Torres Strait, the Gulf of Carpentaria, the Arafura Sea, and the deep Mesozoic and Tertiary basins, with their thick strata as a senkungsfeld. Possibly the crystalline schists forming a great part

of the backbone of the island have played the part of an inner, or "rück-land massif," which has helped to roll up the Mesozoic and Tertiary sediments. The chief fracture zones, on which the present active volcanoes of Mount Victory and Dobu are situated, appear to lie on the inner limb of the fold region, just the portions which have been put in tension as the result of the southerly creep of the Papuan area towards Australia.*

The latest crust movements have caused an emergence of the land to the amount of 1,000 feet on the northern coast, and over 2,000 feet on the southern coast in Post Pliocene time.

* If this interpretation is correct their situation would be analogous to that of the Vesuvian volcanic zone in regard to the folds of the Apennines, the lavas of Hungary in reference to the folds of the Carpathians, the lavas of the Great Basin region of the United States of America in regard to the folds of the Rockies and Sierra Nevada, etc.

CHAPTER VIII.

ASTRONOMY AND GEODESY IN AUSTRALIA.

By Pietro Baracchi, F.R.A.S., Government Astronomer of Victoria.

SYNOPSIS.

1. ASTRONOMY.

(a) Astronomical work done by Navigators, Surveyors, etc., for Geographical Purposes.

Sir Thomas Brisbane laid the foundation of Australian astronomy in 1821, but the record of astronomical observations made on Australian soil commences half a century earlier; as is well known, Captain Cook was selected by the British Admiralty, chiefly for his astronomical qualifications, "to conduct his famous expedition to the islands of the Pacific for the purpose of observing the transit of Venus of 1769, which he successfully accomplished at Otaheite, after which he discovered and visited several islands in the Pacific, and eventually re-discovered New Zealand on the 6th October, 1769, and observed the transit of Mercury on 9th November, at a place on the north-east coast, now called Mercury Bay, and sailing north, on 31st March, 1770, he discovered New Holland, landed at Botany Bay, and (on 22nd August, 1770) took possession of the eastern coast of Australia in the name of Great Britain" (1). *

In regard to longitudes obtained by lunar distances, Cook wrote "This method of finding the longitude at sea can be depended upon to within half a degree. Which is a degree of accuracy more than sufficient for all nautical purposes."

From Captain Cook's astronomical observations made on Australian soil in 1770 was derived the first value on record of the longitude of Fort Macquarie, Sydney, viz., 151° 11′ 32″ east of Greenwich, which is almost identical with that determined by Flinders 33 years after (151° 11′ 49″).

Captain John Hunter and Lieutenant Bradley determined the longitude of Port Jackson by a series of lunar distances, observed between 14th March and 28th April, 1788 (Hunter's *Historical Journal*, pp. 87–88). On 17th August, 1788 "we began at this time to take equal altitudes for ascertaining the exact rate of the time keeper."

* A list of the authorities referred to in these pages is given in Appendix A.

In June, 1792, Captain Hunter, in a letter to the Admiralty said "The advantage of being able to ascertain the ship's place in longitude by observations of the moon will be ever satisfactory, but more particularly through so vast a tract of sea, in which the error of the log may considerably accumulate."

(2) The "first fleet," commanded by Captain Phillip, which brought out from Great Britain the colonists who formed the first permanent settlement upon the Australian continent, arrived at Port Jackson in 1788. Colonel Collins tells us, "Among the buildings that were undertaken shortly after our arrival must be mentioned an observatory, which was marked out on the western point of the cove, to receive the astronomical instruments which had been sent out by the Board of Longitude, for the purpose of observing the comet which was expected to be seen about the end of this year (1788). The construction of this building was placed under the direction of Lieutenant Dawes, of the Marines who, having made this branch of science his peculiar study, was appointed by the Board of Longitude to make astronomical observations in this country."

The locality where this observatory is built is known as Dawes Point, and the structure is still there, though not used for astronomical purposes. This may be regarded as the first substantial observatory erected in Australia purely in the interests of astronomy.

The expected comet, however, was not seen, and nothing is known about Dawes' astronomical work at this Observatory, except the determination of its geographical co-ordinates, which are latitude 33° 52′ 30″ S., longitude 151° 19′ 30″. A transit instrument was sent to him by Maskelyne, the Astronomer Royal, in 1791.

In regard to this comet, Russell wrote (6) "The comet, for which all these preparations were made, was that which had been observed in 1532 and 1661, and which was generally expected to return about the end of 1788 or the beginning of 1789. It was one of the twenty-four which Dr. Halley had used in his celebrated investigations, in which he proved that comets were subject to the then law of gravitation, and like all other astronomical bodies, revolved about some centre. In 1776, Maskelyne pointed out that this comet would be affected by the major planets, and that for the investigation of this important matter, it was very desirable that it should be observed in the southern hemisphere where it would first be visible; hence the establishment of the Dawes Point Observatory."

In one of the papers by Captain P. P. King (2) is given, amongst the longitude results of several navigators, the value of the longitude found by Admiral Don Jose D'Espinosa while at Sydney on the *Corbetas Descubierta y Atrevida*. This value reduced to Fort Macquarie, is shown as 10h. 4m. 51.91s., which is within a fraction of a second of time of the latest accepted value, and is very probably nearer to the true value than that found by any other navigator.

For more than 30 years after Dawes' watches for the comet, the astronomical record rests entirely on navigators and explorers.

It was during this period that French expeditions were moving about in Australian waters, while surveys of the coast and explorations inland were being conducted by such nautical men as Bass, Flinders, Murray, and

King, and the first explorers inland—Gregory, Blaxland, Evans, Oxley, Cunningham, Frazer, Hume, and others. Skilled astronomical observers, and even accomplished astronomers were to be found among these explorers, and the sun, the moon, the planets, and the stars were, no doubt, closely watched and employed by them for the determination of their geographical positions.

Flinders, who first circumnavigated Australia in 1801 on the *Investigator*, was indeed an enthusiastic and most accurate observer of the heavenly bodies. It was he who trained Sir John Franklin, then a midshipman on the *Investigator*, in astronomical work. John Crossley, of Greenwich Observatory, was appointed by the Admiralty as the astronomer of the expedition, but left the ship at the Cape of Good Hope, to return home invalided, and Flinders wrote to the authorities offering to undertake the astronomical work himself, with the help of his brother Lieutenant Sam W. Flinders, but the Admiralty sent out to him another astronomer—Inman—who accompanied Flinders during the latter part of the voyage (3). Inman, on his return to England, became Professor of Astronomy, at the Royal Naval College of Portsmouth.

The amount of Flinders' lunar observations is remarkable, both for its fine quality and its large quantity. His value of the longitude of Fort Macquarie (Sydney), "151° 11′ 49″" east of Greenwich, is probably within one mile of the true value which, considering the instrumental limitations and the inaccuracy of the lunar tables in his day, may well be accepted as a result of the highest accuracy attainable at the time. In his *Voyage to Terra Australis*, are given the geographical co-ordinates of many places on the south coast of Australia (Vol. I., 1814), App., page 259.

(2) Lieutenant (afterwards Admiral) P. P. King, son of Governor King, arrived at Port Jackson in September, 1817. He had been sent by the British Government to complete the surveys of the coast of New South Wales, which, then, extended from South Cape in Tasmania, latitude 43° 39′ S. to Cape York, 10° 37′ S.

He made four voyages, extending over four years, from 1817 to 1822, during which he determined the longitude and latitude of a large number of points on the coast.

The results of the survey were published in his work *A Narrative of a Survey of the Inter-tropical and Western Coasts of Australia* (2 Vols., 8vo., London, 1847).

From 1826 to 1830 he was in command of two ships—*Adventure* and *Beagle*—conducting surveys on the southern coasts of South America. Shortly after, he retired from active service and settled in New South Wales, where for the rest of his life he continued to devote himself to scientific work, "during his residence at Dunhered, from 1832 to 1839, and at Tahlee, Port Stephens, to 1848, kept his observatory in full work with the transit and other instruments" (2).

The results of his astronomical work are contained in two papers which were printed "at his own private printing press, apparently for private distribution, a copy of each of which is in the possession of his family." and in another paper, containing the first five years observations at Tahlee, which was published in the *Tasmanian Journal*, No. 6, a copy of which is

in the Sydney Observatory, with the remainder of the observations in MSS. In one of the two papers first mentioned are recorded "the observed transits of the moon and moon culminating stars over the meridian of Tahlee, Port Stephens, New South Wales, from 1843 to 1849, and the resulting longitudes from them. Also observations of eclipses of the sun and occultations of the fixed stars by the moon at the same place." The derived longitude of the station is 10h. 8m. 11s.

"The second paper gives a description of the instruments in the observatory and the observations for determining the latitude of Tahlee, 1841 to 1848. These observations were made with an altazimuth. Nearly 300 separate star observations for latitude are recorded, from which the latitude 32° 40′ 17·74″ is derived. Also a list of about one thousand places for which the geographical co-ordinates are given."

Admiral King published in addition eight papers in the Monthly Notices of the Royal Astronomical Society, "Four refer to comets, amongst others the great comet of 1843; one to an occultation of Jupiter and his Satellites; another to a lunar eclipse; another to a transit of Mercury; and the last to a solar eclipse" (2).

Sir James Ross' antarctic expedition arrived at Hobart (Tasmania), in August, 1840, in the ships *Erebus* and *Terror*. Sir John Franklin was then Governor of that Colony.

A vigorous campaign for the acquisition of data in regard to the magnetic conditions of the globe was in course at the time, under the influence of Gauss and Sabine, and Sir James Ross established a magnetic station at Hobart, and also an astronomical observatory, where a transit instrument, an altazimuth, and astronomical clocks were permanently mounted. This station was placed in charge of Lieutenant Kay. Although terrestrial magnetism was the principal object, astronomical observations were systematically made and continued till 1854.

An elaborate investigation of the difference of longitude between Hobart and Port Macquarie (Sydney), Parramatta, and Cape of Good Hope, is included in the work of this observatory.

(b) Astronomical Work done in Australia by the Permanent Government Observatories.

The Parramatta Observatory, though originally a private establishment, became the property of the New South Wales Government, and is for this reason placed under this heading.

The Parramatta Observatory.

In 1821, Major-General Sir Thomas Macdougall Brisbane was appointed Governor of the colony of New South Wales. Throughout his career as a soldier he had always been devoted to astronomy, and as the southern heavens offered him almost a virgin field for exploration, he urged the British Government to supply him with means for establishing an observatory in the country he was being sent to govern, but having failed, he undertook to carry out the idea at his own cost. Accordingly he purchased instruments, books, and appliances, engaged two assistants, and immediately after their arrival in the colony, in November,

1821, a site was selected in close vicinity to his official residence at Parramatta, upon which a suitable building was quickly erected for the installation of the instruments, and by the following April the Parramatta Observatory was already in full working order.

The assistants were Carl Rumker, an accomplished astronomer who later became Director of the Hamburg Observatory, and James Dunlop, whose great natural abilities, especially mechanical, rendered his services particularly valuable in a place where no skilled instrument makers were available.

The instruments (4) "were a transit instrument by Troughton, of 3¾-inch aperture and 64-inch focal length; a 2-foot mural circle, with telescope of the same length, by the same maker; a 16-inch repeating circle, by Reichenbach; a 46-inch achromatic telescope, with equatorial motion and wire micrometer, by Banks; a clock, by Hardy, set to sidereal time; and another, by Breguet, showing mean time." Also two other clocks, by Grimaldi and Barraud; a box chronometer, by Dent; and a pocket chronometer.

The programme of the Parramatta Observatory was principally the determination "of the position of stars down to the eighth magnitude, between the zenith of the observatory and the South Pole"(4).

The regular series of observations was commenced on 2nd May, 1822. At first, Sir Thomas Brisbane and his two assistants worked together harmoniously and with great assiduity, but on 16th June, 1823, Rumker left the observatory, and from that date till December, 1825, the greater part of the observations were made by Dunlop.

In December, 1825, Sir Thomas Brisbane returned to England, and Dunlop followed him towards the end of the following year, after having continued the work at Parramatta Observatory till 2nd March, 1826, and completed a series of observations of 621 nebulae and clusters, at his private house, with a reflecting telescope, 9 inches aperture and 9-feet focal length (2) made by himself (5), and a catalogue of 253 double and triple stars which he observed during the same period (5).

The records of the observations made at Parramatta with the transit instrument and the mural circle, from 2nd May, 1822, to 2nd March, 1826, were placed in the hands of Mr. Richardson, of the Greenwich Observatory, in 1830 "by order of the Honorable the Lords Commissioners of the Admiralty, who directed him to reduce the observations and construct a catalogue of the positions of the stars" the result being the well-known Parramatta Catalogue of 7,385 Stars for the Epoch 1825, published in 1835.

The re-discovery of Encke's comet at its first predicted return may be justly regarded as one of the brilliant records in the history of the Parramatta Observatory. The comet was re-discovered by Rumker on 2nd June, 1822.

After the departure of Sir Thomas Brisbane, the observatory was taken over by the Colonial Government, on payment of the full cost of its equipment, to the owner, and placed in charge of Rumker, who became the official astronomer, and resumed work in May, 1826, after having, on 15th July, 1824, discovered a new comet—I 1824—which bears his name (10). He made many observations for latitude and longitude, and observations of the moon, the planets, and comets. The results are published in the *Philosophical Transactions of the Royal Society*, 1829, Part III., and in the *Memoirs of the R.A.S.*, Vol. III.; also in Vol. I. of the *Monthly Notices*.

At the end of the year 1828, he went to Europe, and some time after became Director of the Hamburg Observatory.

The Parramatta Observatory remained inoperative for nearly three years. In 1831, Dunlop returned to Australia, and was appointed Superintendent of the Parramatta Observatory, which position he held till 1847.

Most of the work done by Dunlop during this period still remains unpublished. It is contained in eight books MSS., which were transferred to the present Sydney Observatory (2).

(7) On 30th September, 1833, Dunlop discovered a comet, and on the 19th of March, 1834, he independently discovered another, which had been first seen by Gambart, at Marseilles, twelve days before (8).

The observations of these comets are published in *Memoirs of the Royal Astronomical Society*, Vol. 8, page 251 *et seq.*

The Catalogue of 629 Southern Nebulae and Clusters, observed by Dunlop, in 1828, with a 9-inch reflecting telescope of his own make, as previously mentioned, was presented to the Royal Society, and printed in the *Transactions* of 1828, pp. 113 and 152, and the Catalogue of 253 Double Stars, observed in the same year, was published in the *Memoirs of the R.A.S.*, Vol. III.

After Dunlop's resignation, the observatory was dismantled, the instruments packed and stored, and Australia remained without an astronomical observatory for several years.

In 1880, when the building which had once been the Parramatta Observatory was reduced to ruin, fast disappearing, the Government was induced to erect a permanent monument to indicate the site of the observatory.

Exactly in the position occupied by the transit instrument, a marble obelisk now stands, with the following inscription:—"An Astronomical Observatory was founded here May 2nd, 1822, by Sir Thomas Macdougall Brisbane, K.C.B., F.R.S., Governor of New South Wales" (6).

The geographical co-ordinates of this historical point, assigned to it by Rumker, are Latitude 33° 48′ 50·68″, Longitude 101° 4′ 6·25″

Although the admitted imperfections of Sir Thomas Brisbane's astronomical equipment, and his desire to accumulate data from direct observation at very high speed must be recognised as the concurring causes which prevented a degree of accuracy equal to modern needs to be attained in the Parramatta Catalogue—which represents the main results of Sir Thomas Brisbane's enterprise—thus reducing to some extent the value of the work done by him and his assistants, we must nevertheless regard that enterprise with profound admiration and look upon the obelisk now standing on the spot where Sir Thomas Brisbane, Rumker, and Dunlop observed the stars crossing the meridian of Parramatta, as the monument raised by an appreciative generation to commemorate the foundation of Australian astronomy.

The founder of the Parramatta Observatory and its successive directors were indeed held in high estimation in England

The Royal Astronomical Society presented its gold medal to Sir Thomas Brisbane and James Dunlop on 8th February, 1828, and to Carl Rumker on 10th February, 1854.

The Sydney Observatory.

This observatory is situated on one of the headlands projecting into the Harbor, on the western side of Sydney Cove, less than half a mile from Dawes Point, where Lieutenant Dawes erected the first Australian observatory, in the year 1788. The locality is now called Flagstaff Hill.

Through the persistent recommendations of Sir William Denison, Governor of New South Wales, soon after his arrival in Australia, on 20th January, 1855 (6), the Colonial Government voted a sum of £7,000 for the erection of an observatory in Sydney, and made provisions for the salary of an astronomer and a computer.

The Reverend W. Scott, M.A., was selected by the Astronomer Royal, Sir George Airy, to fill the position of first director of the proposed Sydney Observatory.

The first duty of Mr. Scott after his arrival was, as he relates himself, "to fix on a site for the proposed observatory. For purely astronomical purposes I should have preferred a position further inland, but as it appeared desirable for various reasons that the observatory should be in the immediate neighbourhood of Sydney, I could find no spot more suitable than that recommended by the Governor on which the observatory now stands."

The building was commenced in May, 1857 and was so far advanced as to admit of meridian observations being made in June, 1858."

The first astronomical equipment of the Sydney Observatory consisted of the instruments purchased by the Government from Sir Thomas Brisbane. In addition, a complete time-ball apparatus was installed. By means of this apparatus the ball on the tower was automatically dropped, at first at the instant of local noon, and later at the instant of 1 p.m. It was chiefly the practical value of this service which gave the Government sufficient inducement to establish the observatory and, at the same time, imposed the essential conditions in the selection of the site.

The work of the observatory was confined in the first instance to the approximate determination of the sidereal and thence the mean time by a number of nightly observations of clock stars (9).

The transit circle by Jones, with which Dunlop had in his later years made a few observations at Parramatta, had been sent to England to be remodelled and improved by Troughton, and did not arrive back till December, 1858. This instrument has an object glass of 3¾ inches aperture and 62 inches focal length. Its circle is 12 inches in diameter, divided to every 5′ and read by four microscopes 90° apart. It was completely set up and ready for use in June, 1859.

Mr. Scott complains that this instrument was not entirely satisfactory. He says (9), "The instrumental errors are such that although the circle may be regarded for some purposes as an useful instrument yet it cannot be classed amongst instruments of the highest order."

(6) "It was a fortunate circumstance that just then, in October, 1858, the great comet of Donati, one of the finest in the century appeared in our southern sky," for it served the purpose of drawing the attention of the authorities to the want of a suitable instrument at the Official Observatory for the observations of the comet and of obtaining from Parliament a sum

of £800 with which an achromatic telescope, 7¼-inch aperture and 124 inches focal length, made by the celebrated firm of Merz and Son, of Munich, was purchased, which was mounted and ready for use in June, 1861.

Mr. Scott remained in office for four years, and resigned his position on 30th September, 1862.

The astronomical work done at the Sydney Observatory in Mr. Scott's time was fully published by him in the four official volumes issued for the years 1859, 1860, 1861, and 1862. These contain the results of upward of 6,600 meridian observations in both co-ordinates, about 100 transits of the moon and moon culminating stars, a large number of observations of zenith stars for latitude, and some observation of comets.

The 7¼-inch Merz equatorial was at his disposal only fifteen months, during which some attention was given to double stars.

Mr. Scott published some of his other astronomical work in the *Monthly Notices of the R.A.S.*, Vols. 19, 20, 21, and 22, as follows:—Observations of the Solar Eclipse of the Sun, 11th January, 1861; Comet III., 1860; Comet II., 1861; Encke's II., 1862; Transit of Mercury N 4, 1861.

The instrumental faults never permitted Mr. Scott to assign to his meridian observations a degree of accuracy equal to that of the best observatories.

"It must therefore be borne in mind" he tells us "that determination of right ascension with the Sydney transit circle are liable to errors varying from 3·3 to – 4·2 seconds of arc, or 0·22 to – 0·28 seconds of time for a equatorial star." "An examination of the North Polar distances leads to a very similar result" (9).

From September, 1862 to January, 1864, the Observatory was in charge of Mr. Henry Russell, B.A., who had joined the Observatory as Mr. Scott's assistant in 1859.

Mr. Russell confined his astronomical duties to the time service and to the observation of transits of the moon and moon culminating stars. He also made a series of micrometric measurements for the comparison of Mars with neighbouring stars, at the opposition of 1862. This series, however, was not published (6).

Mr. George Robert Smalley, B.A., succeeded Mr. Scott as the second Director of the Sydney Observatory, in 1864, being selected by the Astronomer Royal—Sir George Airy—at the request of the colonial authorities.

It seems that the imperfection of the meridian instruments as reported by Mr. Scott discouraged Mr. Smalley from undertaking any serious and systematic work with them, and he resolved to employ them only for the ordinary requirements of the time service. He devoted the rest of his time to magnetic and meteorological investigations and to the initiation of a trigonometrical survey of the colony, which was then urgently required. Eventually the Government intrusted him with that work, and operations were commenced in due course for the measurement of a base line at the south end of Lake George.

Difficulties and delays were encountered in these operations and the worry "told seriously on Mr. Smalley's health, and during the latter part of 1869 and all 1870 till his death in July of that year, he was not able to do much of the work which he had determined to carry out" (6).

The only astronomical work done during these years, in addition to the observation of clock stars, were some observations of Comet I., 1864, made by Mr. Smalley with the Merz 7¼-inch equatorial, and published in the *Monthly Notices of the R.A.S.*, Vol. 25, p. 171; and observations of Comet I., 1865, and of Encke's Comet at its return in 1865, which were published in *Monthly Notices*, Vol. 26, p. 63.

Mr. Russell succeeded Smalley as third Director of the Sydney Observatory and Government Astronomer of the colony of New South Wales.

"Having had a share in all the work done with the meridian circle, and knowing its imperfections, he determined to confine the observations with it to those required for time and longitude, and at once urged the necessity for a new meridian instrument" (6).

The approaching transit of Venus gave him the opportunity of obtaining the sympathy of the Government for the acquisition of more instruments.

The astronomical operations which figure more prominently in the history of the Sydney Observatory during the first seven years of Russell's regime are the preparations made for observing the total eclipse of the sun in December, 1871, in the extreme north of Australia, and the transit of Venus in 1874, of which a brief account will be given in another part of this article.

To the ordinary routine of observations of clock stars were added observations of the transit of the moon and moon culminating stars for longitude, and the observations of Herschel's Cape Catalogue of Double Stars.

A remarkable feature of this period is the increase of instrumental power which Russell, by continuous effort and determination, succeeded in securing for his observatory.

In 1872, with the assistance of the Royal Society of New South Wales, he obtained from the Government a sum of £1,000 for instruments, the greater part of which he used in procuring an achromatic object glass, 11.4 inches aperture, and 12½ feet focal length, by Schroeder, of Hamburg, for which he designed and had constructed in the colony under his supervision an equatorial mounting provided with all the requisites of a modern instrument. This instrument was installed in 1874.

In the same year the necessity having arisen for the determination of star positions with the greatest possible accuracy to serve the purposes of the trigonometrical survey of the colony of New South Wales then in course a sum of £1,000 was granted by the Government for the purchase of a high-class transit circle for the observatory; Mr. Russell ordered the instrument from the firm of Troughton and Simms, and procured also a large eighteen-prism spectroscope, by Hilger, and other apparatus.

The new transit circle has an object glass of 6 inches clear aperture and 85 inches focal length. It has two circles graduated to every 5′ read by four microscopes; regular observations with it were commenced in February, 1877.

The instrument was employed for observations of stars required in the operations of the trigonometrical survey, and of other stars near the zenith, of which it was intended to make a special catalogue.

"In fact, since 1870, the observatory has been entirely refurnished with instruments of the most modern and perfect forms, and, although they are not equal in size to some of the giant telescopes which have been recently erected in Europe at enormous cost, they are quite equal in quality to those in the best European observatories, as is proved by the observations now made with them." Thus Russell wrote in 1882 (6).

An important series of meridian observations of Mars at its opposition in 1877 and comparison stars had been obtained by Russell with the new transit circle "for the purpose of determining the solar parallax. A long series of observations was made which, combined with observations made at Washington. gave 8·885 inches as the value of the solar parallax" (6).

The results of the work done with the transit circle up to the end of the year 1881 are published in two volumes, "Sydney Observatory—Astronomical results for the years 1877–78 and 1879–1881." These results were used by A. Stichtenoth to form a catalogue of 1,543 stars for the epoch 1880, published in Veröffentlichungen des Königlichen Astronomischen Rechen-Instituts zu Berlin, No. 20.

The results of observations on double stars are published in a separate volume, Sydney Observatory—Double Star Results. 1871–1881.

In the first volume of astronomical results is shown a summary of the observations of transits of the moon and moon culminating stars made by Russell in the years 1863, 1871, 1872, 1873, and 1874, from which is derived the value of the longitude of Sydney (according to Russell), 10h. 4m. 50·81s., which was adopted till 1883.

During the eight years after 1881, the same routine of meridian observations and observations of double stars were continued.

The double-star work of the years 1882–1889 was published in Memoirs R.A.S., Vol. 50.

In 1887 Mr. Russell went to Europe to attend the Astrophotographic Congress at Paris, and on behalf of his Government and the Government of the colony of Victoria, pledged the Sydney and Melbourne Observatories to undertake a share in the astrophotographic programme which was decided upon by that Congress.

The part of the sky allotted to Sydney ranged from 57° to 64° of south declination, and that of the Melbourne Observatory from declination –65° to the South Pole.

Russell obtained his photographic object glass from Steinheil, of Munich, and had the mounting, with all requisite accessories, made in the colony on his own design, and under his personal supervision. He had a circular wooden observatory detached from the main building, built for the special purpose of housing this astrophotographic telescope.

The mounting of the astrograph was ready in 1890, but the object glass did not arrive till later. Russell, in the meantime, mounted a Dallmeyer portrait lens 32 inches focal length and 6 inches aperture, and, fixing this star camera to the tube of the astrograph, employed it in taking a series of highly successful photographs of the Milky Way. These photographs, seventeen in number, accompanied by a description of each, form an album which was published in 1890.

The installation of the new object-glass was completed in 1891, and the work reached the end of the preliminary experimental stage in 1892, from which time it proceeded regularly in succeeding years till 1898.

In 1889 powerful street lamps and electric lights were placed in the vicinity of the Observatory, the effect of which was to interfere so seriously with the work of the astrograph that it became necessary to remove the instrument to some better locality.

Accordingly, the Government, having granted a piece of land for this purpose at Pennant Hill, some $11\frac{1}{2}$ miles to the north-west of Sydney, and 615 feet above sea-level, a suitable building was erected, and the instrument installed there in 1899, where the astrophotographic work has since been carried out by Mr. Short, as a branch of the Sydney Observatory.

For the last 22 years the determination of the places of reference stars to be employed for the reduction of the plates of the Photographic Catalogue, and actual photographing of the regions comprised in the Sydney zones, constituted the greater part, if not the whole, of the astronomical programme of the Sydney Observatory, the results of which have not yet appeared.

During this long period observations of double stars were continued, the results of which have been published in various lists in the A.N., Nos. 3154, 3240, 3303, 3369, 3423.

Many other observations of an occasional character were made, and other astronomical duties performed, which come within the scope of a national observatory, but it would be impracticable to give here a detailed account of them.

Russell, who died in 1907, may be regarded as one of the principal factors in the advancement of Australian astronomy during the last half century. In estimating the value of his work, it must be remembered that by far the greater part of his energies were expended on the development of Australian meteorology.

He was the inventor of no less than 23 instruments, and the contributor of some 130 papers to various scientific societies. He was made F.R.A.S. in 1871, F.R.S. in 1886, C.M.G. in 1891, also, in the same year, Vice-Chancellor of the Sydney University, where he graduated in 1858, and President of the R. S. of New South Wales for some years.

After Russell's death, Mr. Alfred Henry Lenehan was appointed Government Astronomer. Under him the astronomical work of the Observatory was a continuation of the routine programme of previous years, which he was bound to accept and to advance as speedily as he could, under the administrative difficulties of the time, till completion might be reached.

He died on 2nd May, 1908; and till August, 1912, Mr. W. E. Raymond remained in temporary charge of the institution.

In August, 1912, Mr. W. E. Cooke, M.A., formerly Director of the Perth Observatory, was appointed Government Astronomer of New South Wales, and Professor of Astronomy in the Sydney University.

In his report to the R.A.S., M.N., February, 1913, No. 4, Vol. LXXIII., we read—

"Owing to the rapid growth of Sydney, the present site of the Observatory has become unfit, and the instruments are not suited for the exacting requirements of modern astronomy. It has therefore been determined to

move the entire institution to a new site, and to provide some new instruments and remount others. In particular, a new meridian instrument of modern design, suitable for fundamental work of the highest precision, will be provided in accordance with the recommendation of the Paris Astrographic Congress of April, 1909.

"Meanwhile the routine work has been almost stopped for the present, and preparations for the reorganization have been commenced."

The Williamstown Observatory.

R. L. J. Ellery was appointed, in 1853, by the Government of the Colony of Victoria to establish a small observatory at Williamstown, chiefly for the purpose of determining time and supplying a daily time signal for the service of ship masters.

On taking up his position, Ellery found the following preliminary arrangements already made :—

A time ball apparatus already installed on a tower at Point Gellibrand, with the requisite apparatus and machinery for hoisting and dropping the ball.

Some astronomical instruments, including a transit instrument on order in England.

A site for the Observatory selected.

A sum of £2,800 voted by Parliament for the erection of a suitable building.

Under these conditions he set to work in a wooden hut, using a sextant and a chronometer, and the first time signal was issued in August, 1853.

Such was the beginning of the Williamstown Observatory.

The geographical position of the place had been determined some years previously by Captain Stokes, of H.M.S. *Beagle*, his values being—

Latitude 37° 52′ 52″ S. Longitude 9h. 39m. 12s. E.

In 1854, the instruments on order in England arrived. They were a 25-inch transit instrument and a high-class astronomical clock, by Frodsham.

A more ambitious transit instrument, which had been ordered from the firm of Troughton and Simms, arrived in 1855. This was an excellent instrument, with an object glass of 3½ inches clear aperture and 45 inches focal length.

In 1858, the geodetic survey of the colony was decided upon, and placed in charge of the astronomer. The proposed scheme was to divide the country for purposes of land settlement by meridians and parallels, the primary lines being first located at distances of 1°.

The Observatory having by this time acquired national importance, on account of its public duties in connexion with the geodetic survey and time service, the Legislature passed a resolution on 8th December, 1859, according to which a Board of Visitors to the Observatory was appointed by the Governor in Council on 30th January, 1860, the Governor (Sir Henry Barkly) becoming himself chairman of the first Board.

A new circle arrived in August, 1861. It was constructed by Troughton and Simms. Its object glass has a clear aperture of 5 inches and a focal length of 72 inches. The circle is of gun metal, 4 feet in diameter, divided

to every 5 minutes, and read by four microscopes attached to one of the two stone piers which support the instrument. Observations with this instrument commenced in October, 1861.

A new clock, also by Frodsham, had arrived a year before, and still more instruments were acquired in this and in the following year. These were a chronographic apparatus, by Siemens and Halske, of Berlin; an Airy zenith sector: and an achromatic telescope, equatorially mounted. This latter instrument, by Troughton and Simms, has an object glass of 4½ inches clear aperture and a focal length of 5 feet: with it a valuable series of observations of Mars at its opposition of 1862 was obtained for determining the parallax of the sun in connexion with other observatories.

In 1853 the site occupied by the Williamstown Observatory seemed quite suitable for an observatory, but the rapid growth of the community, the construction of a railway terminus and large railway workshops near it, had in 1862 rendered its position unfavorable, in consequence of which it was decided to remove it to Melbourne.

Since 1857, there had been in existence a meteorological and magnetical observatory, which was established and conducted by Professor George Neumayer. This observatory was situated at Flagstaff Hill, at the west end of the city of Melbourne. In 1863, Professor Neumayer, having decided to leave Australia, it was arranged that his observatory should be amalgamated with the new Astronomical Observatory.

The building for the new Observatory was commenced in 1861 and completed in 1863.

In June of that year the Williamstown Observatory was dismantled, and "the whole of the instruments and appliances removed to the new building now known as the Melbourne Observatory" (11).

The results of the work done at the Williamstown Observatory are published in the volume entitled—Melbourne Observatory. Astronomical Results. 1861–62–63.

This volume contains the Williamstown catalogue of 546 Stars for the epoch 1860, which at the time it appeared received warm appreciation from European and American astronomers. Also a series of right ascensions and north polar distances of the moon, extending from January, 1861, to 7th October, 1862, upon which rested the longitude of the Williamstown Observatory; and finally, the series of observations of Mars and comparison stars during the opposition of the planet of 1862.

The Melbourne Observatory.

This Observatory is situated at a distance of 4 miles north-east from the site of the old Williamstown Observatory, and about 1 mile south-east from the centre of the city of Melbourne, within an enclosure of 4½ acres of land permanently reserved for observatory purposes in the Domain Park.

In addition to the main building, which provided ample accommodation for the astronomical instruments of the Williamstown Observatory, special structures were erected for the magnetic and meteorological instruments which were taken over from Professor Neumayer's Flagstaff Hill Observatory.

The Melbourne Observatory was ready to commence work at the end of June, 1863, its astronomical equipment consisting of the instruments removed from the former Observatory at Williamstown.

For nearly three years the work consisted almost entirely of meridian observations of the fixed stars which were employed in the operations of the geodetic surveys then in course in Australia and South America. A catalogue of these stars was prepared each year and printed in due course.

In 1862 the Royal Astronomical Society initiated a movement for carrying out by British effort a southern durchmusterung on the same basis and the same scale as that which Argelander was conducting for the northern hemisphere. The idea was to obtain the co-operation of the three southern observatories—Madras, Cape of Good Hope, and Melbourne.

The Melbourne Observatory offered to join in the work, and was eventually allotted the zone from 60 degrees to 80 degrees of south declination.

The undertaking involved the determination of the positions of all the stars comprised in this southern belt down to the tenth order of magnitude.

This work was commenced on 11th April, 1866, and continued for about six years, when it had perforce to be discontinued. Its results comprise the mean places for the epoch 1875 of 48,672 stars down to the 9th, and in many instances the 10th order of magnitude, in the zone from 65 degrees to 69 degrees of south declination. These places are roughly arranged in the MS. in order of right ascension, the right ascensions being given to the nearest tenth of a second of time, and the north polar distances to the nearest second of arc, showing that the work aimed at a somewhat higher accuracy than that of other works of this class, such as Argelander zones or the C.P.D.

With very little labour the work can be arranged and prepared for printing if means be provided for the purpose.

In the year 1850 a memorial was presented to Lord Russell, the object of which was a request to Her Majesty's Government to establish "a powerful reflecting telescope (not less than 3-feet aperture) in some fitting part of Her Majesty's Dominions, and for the appointment of an observer charged with the duty of employing it in a review of the nebulae of the southern hemisphere."

The opportunity of enhancing the importance of the Observatory by the acquisition of a great reflecting telescope was quickly recognised by the Board of Visitors, and His Excellency the Governor (Sir Henry Barkly) was requested to obtain "an expression of opinion from scientific men in England as to the importance of the results to be expected from it, the most suitable construction of telescope for the purpose, both as to the optical part and the mounting, its probable cost, and the time requisite for its completion."

"An application was made through the Secretary of State for the Colonies to the Royal Society of London for their opinion, and the President and Council of that body, after a very full consideration and a long correspondence with the most eminent practical astronomers of the day, recommended—(*a*) That the telescope be a reflector, with an aperture of not less than 4 feet; (*b*) That the large mirror be of speculum metal; (*c*) That the tube be constructed of open work and of metal" (12).

The instrument was completed in 1868 and was sent to Australia, reaching Melbourne in November of that year: it was ready for work by the end of June, 1869, and the observations commenced in August of the same year.

Grubb's 4-feet reflector has, since its installation, been styled "The Great Melbourne Telescope." An admirable description of it by the late Dr. T. Romney Robinson, D.D., F.R.S., appears in the *Philosophical Transactions of the Royal Society of London*, 1869, page 127 (13).

The telescope itself is of the Cassegrainian type, and is mounted equatorially in a somewhat similar form to the Sisson: "its declination axis being placed between the upper and lower pivots of the polar axis, which run in large bearings, supported by two distinct massive stone pillars rising from a solid bed of masonry. The R.A. circle clamps and slow motion apparatus are between the declination axis and the lower pivot. The declination circle is fixed to the bearings of the declination axis on the side of the polar axis, opposite to that of the telescope" (13).

The dimensions of the optical parts are as follow:—Aperture of primary speculum, 48 inches; focal length of primary speculum, 360 inches; aperture of secondary speculum, 8 inches: focal length of secondary speculum, 74.7 inches: equivalent focal length, 1,994 inches.

There are two large 4-feet mirrors, each mounted in its cell ready for attachment to the telescope, floating on a complicated support of 18 cups and balls connected to the ends of arms which form a series of triangular levers, and upon hanging rings around its circumference. These mirrors have a central circular opening of 8 inches in diameter to admit the passage of the cone of rays from the convex secondary mirror to the ocular. The mirrors, both primary and secondary, are of speculum metal.

The tube of the telescope consists of three portions. The lower, or "eye end" portion consists of the cell carrying the large speculum: the central portion is a cylinder of boiler plate, about 93 inches long, to which is attached the declination axis by means of a massive cast-iron cradle and strong iron bands embracing the cylinder. The speculum cell fits to the end of this cylinder on turned surfaces, and is held to it by three strong screw-bolts. The upper portion of the telescope tube is made of open steel lattice-work, about 20½ feet long, fixed by turned flanges to the boiler plate cylinder by bolts and nuts.

The secondary mirror, in its cell, is mounted in the centre of the lattice tube, about 300 inches from the surface of the primary speculum and 39 inches within the object end of the tube, and means are provided to enable the observer while at the eye end to alter this distance for focussing.

The polar axis is 123 inches long, and its two pivots are 12 inches in diameter. The declination axis has a diameter of 22 inches at the bearing near to the telescope, and 9½ inches at the counterpoise end. The circles are divided on silver bands, and have a diameter of 30 inches.

The driving clock is governed by a double conical pendulum of the well-known "Grubb" form. The direct driving weight is 260 lbs., and the total weight of the moving parts is approximately 18,000 lbs.

The instrument is provided with an achromatic telescope finder, 4 inches aperture, seven negative or Huygenian eye pieces ranging in power from

234 to 1,000, a parallel wire micrometer, a spectroscope, and a camera for photographing telescopic images at the focus of the primary mirror, the secondary mirror being removed when the camera is used.

In 1910, a Voigtlander portrait lens of 6 inches aperture and 40 inches focal length, for which a metallic mounting was made at the Observatory, was attached to this telescope.

The great Melbourne telescope was for many years after 1869 employed in the revision of the nebulae and clusters which were observed by Sir John Herschel at the Cape of Good Hope in the years 1834–38, and the results obtained are as satisfactory as the committee of the Royal Society of London, on whose recommendation, supervision, and approval the 4-feet Cassegrain was constructed, could have expected.

Most of Sir John Herschel's southern nebulae have been examined, and many hundreds of drawings of these objects, with notes and micrometric measurements, exist at present in the observer's note books and registers; but there has been no opportunity since 1891 of arranging this material for publication.

In 1871, an expedition to the extreme north of Australia was organized for the observation of the total eclipse of the sun in December of that year, in which the Melbourne Observatory took part. This expedition is referred to in another division of this paper.

In 1874, the occasion of the transit of Venus, which occurred in that year, gave Ellery the opportunity to add to his observatory equipment a photoheliograph, by Dallmeyer, with object glass 4 inches aperture and 60 inches focal length; an achromatic telescope, 8 inches aperture, 110 inches focal length, by Troughton and Simms, mounted equatorially and provided with all requisites for micrometric measurements and work of the highest precision; also another equatorial telescope, $4\frac{1}{2}$ inches aperture and 60 inches focal length, by Cooke and Sons, of York.

The preparations for observing the transit of Venus included the dismantling of the east transit telescope of $6\frac{1}{4}$-inch aperture, with which the Melbourne zones had been observed till 1872. For this telescope an equatorial mounting was constructed at the Observatory, and the instrument has since been used for expeditions as a portable equatorial.

Two new barrel chronographs were also constructed at the Observatory.

After the transit of Venus, it became a part of the daily routine to take a photograph of the sun in the forenoon, which was done on all available opportunities for more than 20 years.

In the time which elapsed between the two transits of Venus of 1874 and 1882, the routine astronomical work of the Observatory did not suffer any marked changes or interruptions.

Stellar photography was tried with the great telescope, but unsuccessfully. It was not found practicable to guide the telescope steadily enough during exposure. Photographs of the moon with the great telescope, which only required an exposure varying from 1 second to 3 seconds (with wet plates) were, however, successful, and they were even considered at the time amongst the best that had ever been obtained.

The photographs of the moon obtained at the focus of the primary mirror were $3\frac{1}{2}$ inches in diameter.

The pictures of the sun obtained with the photoheliograph were 4 inches in diameter. One thousand seven hundred and twelve of these pictures on glass were sent to the Greenwich Observatory and the Solar Physics Committee in England, for measurement and tabulation (14).

The preparations for the transit of Venus of 1882 and the observations of that astronomical event in this State will be dealt with under another heading.

The determination of the difference of longitude between Port Darwin and Singapore, and between Port Darwin and the Australian observatories, which were undertaken in 1883, will also be dealt with separately.

In the year 1883, a "Central Bureau for the Telegraphic Exchange of Astronomical Information" was established at Kiel. It was arranged among the principal Observatories that all urgent astronomical intelligence and discoveries should be communicated to the Central Bureau at Kiel, which would at once transmit the news to various secondary centres to be established for the purpose in every part of the world, and thence to all astronomers concerned. The Melbourne Observatory was requested to act as the secondary centre for Australia, and it has since been its duty to communicate to the other Observatories of Australasia any astronomical news cabled from Kiel, and to receive announcements of astronomical discoveries or other important astronomical intelligence from any part of Australasia for telegraphic transmission to the Central Bureau at Kiel.

Until August, 1884, all meridian observations were made with the 5-inch transit circle, and the results were published in seven volumes, the first of which contained the work done at Williamstown as already mentioned. The six subsequent volumes contain all the separate results from each observation and the annual Catalogues of concluded Right Ascensions and North Polar distances for each year.

The first general Catalogue for the Epoch 1860, containing the positions of 546 stars, is that printed in Volume I. A second general Catalogue for the Epoch 1870 was prepared and printed in 1874. This contains the positions of 1,227 stars. A third general Catalogue for the Epoch 1880, containing 1,211 star places was published in 1889.

In May, 1884, a larger transit circle arrived from England, constructed by Troughton and Simms, and is of somewhat similar dimensions and design to those constructed by the same firm for the Observatories of Cambridge, England, and Harvard College, United States of America. Its object glass has an aperture of 8 inches and a focal length of 108 inches. Its two circles are 3 feet in diameter, being divided to every 5 feet, and each read by four microscopes.

The two circles are at opposite ends of the axis, which is 52 inches in length, and has pivots 4½ inches in diameter. The pivot bearings rest on two short iron pillars, which stand on massive stone piers.

The reading microscopes are carried on gun metal circles attached to the short iron pillars.

From August, 1884, to the present time all meridian observations have been made almost exclusively with this instrument.

During the period 1884–1891, the astronomical work of the Observatory was similar in character to that of preceding years.

The meridian observations made with the new transit circle comprised the usual clock stars, a special list of circumpolar stars, which were assiduously observed year after year, stars employed for comparison with comets, stars selected by Dr. Auwers for the formation of a "fundamental Catalogue of Southern Stars," and others in connexion with the reduction of the Melbourne zones and transit of Venus observations; also a list of stars required by the Bureau des Longitudes for insertion in the *Connaissance des Temps*, and another list of stars used by Dr. Gill in some of his heliometer work.

The observations of the southern nebulae with the great telescope, and observations made with the smaller equatorials, comprising extended series of observations of all the comets which were visible from Melbourne, and a preliminary spectroscopic survey of the southern stars brighter than the 5th magnitude, form the bulk of the extrameridional work of this period.

It has been stated in a previous page that the share allotted to the Melbourne Observatory in the Astrophotographic Programme, which was agreed upon at the Paris Congress of 1887, covered the south polar area of the heavens limited by the 65th parallel of south declination.

Some description of the instrument required for this work has been already given. The one for this Observatory arrived in Melbourne at the end of December, 1890.

It was constructed by Sir Howard Grubb, of Dublin, and is similar in all respects to those constructed by the same makers for the same purpose for the Observatories of Greenwich and Cape of Good Hope.

It consists of a double telescope, mounted equatorially on a massive cast-iron stand in what is known as the German model.

The two telescopes are roughly of the same length, but of different aperture.

The larger, which is employed for photographing, has an object glass of 13 inches aperture and 135½ inches focal length, and is corrected for spherical and chromatic aberration for rays close to Fraunhofer's spectral line G.

The smaller telescope is used for guiding the instrument by visual observation during exposure. Its object glass is 10.1 inches aperture and 130 inches focal length. The driving clock is within the stand, and is controlled electrically by a seconds pendulum, the driving being corrected automatically by a system of differential wheels devised by the maker.

In September, 1892, a financial depression necessitated a policy of retrenchment, and for some years the work of the Observatory was hampered by the inability of the Government to adequately support it. The year before the astronomical work of the Observatory had to be reduced to a minimum Ellery wrote in his report of 2nd September, 1891—

> "The work of the year is clearly before us. The Melbourne portion of the photographic charting of the heavens, with its collateral work, will use up nearly all our available working power. The meridian work will largely monopolize the Meridian Observing and Computing Staff, while obtaining photographs, developing, and otherwise dealing with the plates will take up the whole attention of two or three members of the staff both night and day. I propose, therefore, to confine the astronomical work, for the present at least, to the routine meridian observations, coupled with the observations for guide stars, and to the special photographic work with the astrograph, undertaking only such occasional extra meridian work as may from time to time demand attention."

In 1895 the astronomical strength of the Observatory was further very greatly reduced by the retirement of Ellery in June of that year. During his tenure of office he had raised the institution from very humble beginnings to the rank of a "First Order" Observatory.

We were left, a band of four, to carry out the meridian and the astro-photographic work. This band remained the same till 31st December, 1907, after which date a fundamental change took place and a new epoch commenced for the Melbourne Observatory.

The Annual Catalogues of Stars, observed with the 8-inch transit circle from August, 1884, to 31st December, 1912, were regularly constructed and completely prepared for publication, but have not yet been printed. Those of the years 1884–1893 were used for the compilation of the Third Melbourne General Catalogue for the epoch 1890; the work, which contains 3,100 stars, will very shortly be ready for issue.

The Annual Catalogues from 1894 to 1912 contain, in addition to the standard clock and azimuth stars and some 134 zodiacal stars which were observed at the request of the Cape Observatory, all the stars which are employed as standard reference stars for the reduction of the Melbourne plates of the photographic catalogue.

With these annual catalogues, up to the year 1910, a special catalogue of 6,680 standard reference stars for the epoch 1900, all observed at least three times, has been prepared.

The total number of stars of this class required for the full reduction of the Melbourne plates is about 9,160, and 2,480 stars are therefore still required to complete the Melbourne share of the astrophotographic catalogue.

Of this number, 636 stars have been observed three times, 379 twice, and 496 once, while 969 stars still remain to be observed three times. It is estimated that these observations will be completed by the end of 1914, after which an additional catalogue for the epoch 1910 will be prepared.

The series of Melbourne catalogue plates has been completed. A series of chart plates, with single exposures of one hour, covering singly the whole area around the South Pole down to the 65th parallel of south declination, has also been completed. In this series the centres of the plates were set at the even degrees of declination.

Another series of chart plates, with three exposures of thirty minutes each, the three images forming a small equilateral triangle with sides of 8 inches has been advanced to the extent of 431 single regions out of 584 regions comprised in the full Melbourne area. The centres of these triple exposure plates were set at the odd degrees of declination from the 65th parallel to the Pole.

For the measurement of the catalogue plates, an arrangement was made in 1898, by which both the Sydney and Melbourne plates were to be measured at the Melbourne Observatory, at the joint expense of the Governments of New South Wales and Victoria; a Measuring Bureau was created and the necessary staff trained at the Melbourne Observatory for the purpose.

The regular measurements commenced in 1900, but a satisfactory rate of progress was not reached till 1901.

The computation of plate constants for the Melbourne regions and the tabulation of rectilinear co-ordinates for publication are now in course of preparation, and a first volume, containing the zones −65 and −66, is ready for press.

The total number of stars in this catalogue is over 300,000, and will occupy eight quarto volumes of about 300 pages each.

On the 1st December, 1908, the Government of the Commonwealth of Australia took over, and assumed control of, the meteorological services of the various States uniting them under a single Commonwealth Department of Meteorology, and thus the Australian Observatories were freed from a burden which had for a quarter of a century retarded the advancement of Australian Astronomy.

Since the middle of the year 1908 to the present date, the principal parts of the working routine programme of the Melbourne Observatory have still remained the same as those of previous years, namely, meridian observations and astrophotographic operations.

The meridian observations have been made generally upon the reference Stars of the Photographic Catalogue, Southern Stars in Auwers' Fundamental Catalogue, Stars selected for investigation of refraction, personal, and magnitude equation, Clock and Azimuth Stars.

The object of the astrophotographic operations has been to advance a second series of catalogue plates and the series of chart plates with triple exposure.

The progress made in the reduction of these observations and in the preparation of results for publication has already been stated.

The record of other classes of astronomical observations and investigations undertaken during the period is as follows :—A series of 100 photographs and measurements of position of Comet C (1908) Moorhouse ; thirteen photographs and some 300 comparisons with stars of Halley's Comet ; observations of Comet Borelly (1911*e*), Gale (1912*a*), Tuttle (1912*b*), Faye-Cerully (1910*e*), Kiess (1911*b*); observations of Variable Stars of long period, south of declination −30; investigation of the Reseaux Melbourne No. 6 and Melbourne N 23 ; investigation of the division errors of the 8-inch transit circle.

The Adelaide Observatory.

In 1855, the late Sir Charles (then Mr.) Todd was appointed in England Superintendent of Telegraphs and Astronomical Observer for the Colony of South Australia.

It does not appear that any astronomical work had been done in South Australia, except for geographical purposes, before Todd's arrival nor for twelve years after it.

In 1867 the transit instrument of 3½-inches aperture and 45 inches focal length, which had been originally employed at the Williamstown Observatory, was transferred to Adelaide on loan from the Victorian Government, and for the purpose of making meridian observations in connexion with longitude operations required for establishing the position of the eastern boundary of the Colony. It was not until 1874, however, that a suitable Observatory and some astronomical equipment were provided by the South Australian Government for its astronomer. The present Adelaide Observatory was erected in that year.

The astronomical instruments comprised, at first, an astronomical clock by Frodsham, the 3½-inches transit instrument borrowed from the Victorian Government, and an equatorially-mounted telescope by Cooke and

Son, 8-inches aperture, and nearly 10 feet focal length, provided with all the requisite accessories of a first-class instrument. The last-named instrument was employed for the observations of the phenomena of Jupiter's satellites, for the study of surface detail of this planet, and for comets.

Meridian observations were made only for determining local time, a time ball placed on a tower at the Semaphore, 9 miles distant, being dropped automatically from the Observatory at 1 p.m. daily. The first time signal was given on 2nd August, 1875.

In 1880 a transit circle by Troughton and Simms, with object glass 6-inch clear aperture, and 85 inches focal length, was obtained, being similar in design to the transit circle of the Sydney Observatory, except that the two divided circles at the opposite ends of the axis are larger, their diameter being 30 inches.

"The first work undertaken was the observation of stars in Weisse's Catalogue, between 0° and 4° south declination, the intention being to include all stars down to the 10th Magnitude, between 0° and 15° south, a work which would have occupied several years. Exclusive of clock and azimuth stars, we had 4,072 observations in R.A., and 4,099 in N.P.D. of stars in the belt (0-4) referred to, by July, 1892" (15).

This work was then suspended, Todd's attention having been called to the discordance in the observations of N.P.D. in the South and North Hemisphere.

Observations were made, for latitude, of 297 stars near the zenith of Adelaide, 118 stars from 1st to 4th magnitude whose zenith distance ranged up to 30 degrees north and south, observed either during day or night; and 127 circumpolar stars so selected that five or six were observed above and as many below the pole, the same stars being observed in the reverse order after an interval of six months.

Later the zenith distances of 300 stars at all altitudes were observed in the years 1893 and 1894.

These were selected from the Greenwich ten-year catalogue 1880.

180 circumpolar stars were observed for latitude in 1894 and 1895, in addition to a small list of 23 stars, of which several bisections were made at the same transit and the Nadir taken before and after every observation, and another list of 53 stars arranged in three groups—one of stars near the zenith, one of stars about 40° south, and one of stars about 40° north of the zenith. This latter list was observed at the same time at the Observatories of Melbourne and Sydney by arrangement.

For some years after 1897 the astronomical work of the Observatory consisted mainly of meridian observations for time, and occasional observations of comets and of Jupiter's satellites.

The publications of this Observatory have been mainly meteorological, consisting of annual volumes, dating from 1876 to 1907 inclusive. Various astronomical memoranda, such as observations of Jupiter's surface markings, satellite phenomena, eclipses of the sun and moon, etc., are included as appendices to these volumes, and some miscellaneous papers have been printed in the Monthly Notices of the *R.A.S.* and in *Proceedings of the Australasian Association for the Advancement of Science.*

The unpublished work comprises all the meridian observations made with the transit circle since the beginning in 1889, and the physical observations and drawings of Jupiter, of which a large series was obtained in the years 1884 to 1894, together with a set of over 200 drawings, made during the same period, and arranged for publication on an orthographic projection.

Sir Charles Todd retired in December, 1906, and was succeeded by R. F. Griffith, who was appointed Acting Government Meteorologist on 1st January, 1907. He resigned his position at the end of that year to join the newly-created Department of Meteorology under the Commonwealth Government, and Mr. G. F. Dodwell, B.A., was then placed in charge of the Observatory. On 1st June, 1909, Mr. Dodwell was appointed Government Astronomer of South Australia.

The present programme of astronomical work at the Adelaide Observatory is as follows: (*a*) Time determinations; (*b*) Observations of reference stars of Sydney Astrographic Zones; (*c*) Field latitude and longitude determination; (*d*) (Seismology) variables, double stars, and miscellaneous observations with the 8-inch Cooke equatorial.

The observations of variables and double stars have now been commenced by certain members of the local Astronomical Society, the equatorial telescope of the Observatory being used for this purpose.

Negotiations are in progress concerning a proposal to undertake latitude variation work in conjunction with the La Plata Observatory.

The instruments of this Observatory at the present day are those which formed the equipment of the Observatory since 1889, namely, the 6-inch transit circle and the 8-inch equatorial, the additions being only a portable universal instrument, chronometers and other minor apparatus.

The Adelaide Observatory is supported by the South Australian Government and administered as a branch of the State Department of Education.

The Perth Observatory, Western Australia.

This Observatory started its career in 1896 as an astronomical and meteorological institution administered as a branch of the Colonial Secretary's Department, Mr. W. E. Cooke, M.A., being appointed Director.

It is situated upon Mt. Eliza—a sand hill some 200 feet above sea level, rising from the western boundary of and overlooking the city of Perth—and commands an almost uninterrupted view of the horizon on all sides (16).

Its geographical position is—Latitude, 31° 57′ 10·27″ South; Longitude, 7h. 43m. 21·74 east.

The climate of the locality is considered very favorable for astronomical work, except in February and March, and in the winter months, when observing is more frequently interfered with by smoke, cloud or rain.

In the first few years of its existence the Observatory was gradually provided with the following instruments, namely:—An 8-inch reflecting telescope intended for use with a coelostat; a transit circle, by Troughton and Simms, with object glass 6-inch aperture and 71 inches focal length, with two divided circles 30 inches in diameter; a twin astrographic instrument, by Sir Howard Grubb, of the standard pattern and size employed by the observatories co-operating in the international astrophotographic programme; two machines for the measurement of astrophotographic plates, similar to

those employed at Greenwich and Oxford; a 12-inch reflecting telescope; a barrel chronograph, with Grubb's "mouse" control; an astronomical clock, by Victor Kullberg, regulated to sidereal time; a mean-time clock; and two chronometers, a 5-inch theodolite, and minor observatory apparatus, accessories, and appliances.

For some years the astronomical work of the Perth Observatory was confined mostly to meridian observations for local time, for the investigation of instrumental errors of the transit circle and for the accurate determination of its geographical position.

In the year 1900 the Government of Western Australia was invited to carry out the astrophotographic programme originally assigned by the Paris Congress of 1887 to the Observatory of Rio Janeiro, which however, had not been able to start the work. The invitation was accepted, and the photographing of the zones comprised between the parallels of 31 degrees and 41 degrees of south declination was undertaken by the Perth Observatory. This circumstance established the nature of the work upon which the transit circle and the astrograph were to be utilized from that time to the present.

The transit circle was to be devoted to the observation of reference stars within the Perth photographic zones, and the astrograph to obtain the requisite photographs of these zones.

This work commenced in 1901. At first, owing to the meteorological duties of the Observatory, progress was slow, but from the end of 1907, when meteorology became a Federal concern, the work advanced vigorously, as shown by the extensive publication of its results.

The character of the task undertaken by observatories participating in the international astrophotographic programme has been previously described here in connexion with the Sydney Observatory, and it will be sufficient to remark that the Perth zones, ranging from $-31°$ to $-41°$, contain 1,376 regions to be photographed, and that about 10,000 reference stars, distributed within these zones at the rate of three stars per square degree, whose positions had to be accurately determined by transit circle observations, were necessary, according to Mr. Cooke, for the preparation of his photographic catalogue.

To these two classes of work the Perth Observatory has practically devoted the whole of its energies and resources, and is still continuing on the same lines towards the completion of its allotted share.

The entire area covered by the Perth zones has been photographed, the whole series containing 1,376 plates, but Cooke found it desirable to obtain another series, in the taking of which improved methods were introduced, which gave greater uniformity in the results; 662 plates of the second series have been obtained and passed as satisfactory.

Three hundred and three plates of the first series, and 294 plates of the second series, have been measured.

In 1907, Professor Dyson, then Astronomer Royal for Scotland, offered to assist in the measurement of the Perth plates. His offer was gratefully accepted. The first plates sent to Edinburgh were those of zone -40 degrees. At present some 400 plates have been measured there and are practically completed (16).

It is stated by the present Acting Director that the series of plates comprising the Perth section of the photographic catalogue will be completed in two or three years. None of the plates of the chart series have as yet been taken.

In the transit circle observations of the reference stars, Cooke adopted the zone method first introduced by Professor Kustner, of the Bonn Observatory in the observation of his zone stars.

The observed positions depend on three steps, namely :—

1. A fundamental catalogue of a small number of stars. For the present purpose *Auwer's Fundamental Catalog fur Zonenbeobachtungen am Sudhimmel* has been used. This contains, on an average, about three or four stars per hour between the limits of –31° and –41° declination.
2. A catalogue of secondary standards, containing three or four stars per hour for every zone of two degrees between the above limits. The positions of these stars depend entirely upon those of the fundamental catalogue, and about ten observations of each star were taken. This catalogue has been published as the first volume of Perth observations, under the title of *A Catalogue of 420 Standard Stars, etc.*
3. The stars of this catalogue form the basis for the determination of positions of the reference stars, of which four catalogues were published, in 1908, 1909, 1910, and 1911.

The places of 7,561 stars for the epoch 1900 are contained in these catalogues.

The plan of advancing all the various phases of the photographic catalogue as rapidly as possible, by measuring the plates soon after they have been taken, and regulating the transit circle observations according to the requirements of the computers for determining plate constants, and thence the final preparation of manuscript for the printer, enabled Cooke to commence the publication of his section of the work in 1911. Vol. I. of the *Astrographic Catalogue*, 1900, Perth section –31° to –41°, and three other volumes bearing the same title, were issued in 1911 and 1912. In these are registered the rectilinear co-ordinates of 60,481 stars, in the aggregate, resulting from the measurement of 160 plates, which cover a belt round the heavens two degrees wide between 31 degrees and 33 degrees of south declination.

The present director estimates that the whole share of the Perth Observatory in the international astrophotographic work will be fully published by the end of the year 1918, so far as the catalogue series is concerned.

The Government Observatory of Brisbane, Queensland.

The Astronomical Observatory at Brisbane may be said to have been established in the year 1879, when, subsequent to the death of Captain O'Reilly, a gentleman who had a private observatory at his home in South Brisbane, the Government of Queensland purchased his entire outfit, and removed the building to its present location on Wickham Terrace.

The adopted geographical position is—Latitude, 27° 28′ ·00″ south; Longitude, 10h. 12m. 6·40s. east.

The various surveyors-general have successively controlled the Observatory programme of work. This has primarily been governed by the requirements of the Survey Department, and was an integral part of the operations of the trigonometrical survey during its existence. The taking of observations for time and the supervision of its distribution per medium of private lines, time ball, etc., is the only work now performed, and none other is projected under present conditions.

The astronomical equipment is as follows:—

(1) A portable transit instrument, by Troughton and Simms, of 30 inches focal length, and 2½ inches object glass.

This instrument has been in use for about 30 years.

(2) A sidereal clock, by Cochrane, of Brisbane, with Riefler's pendulum, and seconds contact for transmitting clock beats electrically.

(3) Combination chronograph and Morse telegraph instrument, with relay, etc., for recording transits, transmitting and receiving time signals.

(4) A mean time clock, by Kullberg, of London, with seconds and hours contacts, also with electro-magnetic attachment for correcting small errors without touching the clock.

(5) Sidereal and mean time chronometers.

(6) Time-ball apparatus.

For a few years after the establishment of this Observatory the observations for time were made by the late Sir Augustus C. Gregory, a versatile and ingenious scientist and famous explorer, who having then retired from his position of Surveyor-General of Queensland, took up the work as a hobby and for this purpose constructed with his own hands a chronograph, relay, and all the apparatus necessary for electrically recording the observations, including the seconds contact in the sidereal clock.

Tasmania.

In conjunction with the chief meteorological station of this State, a Government observatory was established at Hobart on a very modest scale (reduced indeed to a minimum as an astronomical institution) for the purpose of determining local time and supplying the public and the shipping at Hobart with a daily time signal. The astronomical equipment consisted of a small transit instrument and a time keeper, neither of these being of high class workmanship

Owing to complaints made by the Admiralty, in regard to the occasional uncertainty of the time given by the Hobart Observatory, the Government of Tasmania arranged with the Victorian Government for the daily transmission of a time signal at 1 p.m. from the Melbourne Observatory, which has been used since 1911 for dropping the time ball at Hobart, and is repeated to other places in that State.

Thus the State of Tasmania is at present without official astronomy.

(c) Amateur Astronomy.

The astronomical work considered under this heading is that which has been produced by Australians for the love of it and not for pay, nor as a discharge of official functions.

In the popular mind, amateur efforts are frequently associated with the idea of inferiority, but the persons who will be referred to in this division of Australian Astronomy need not fear that the adjective "amateur" is given to them with any intention on my part of underrating their abilities as astronomers or of placing them and their work in a class below that of officialdom. The name of John Tebbutt will be found amongst them. They are, therefore, in good company, and may well be proud of it.

The astronomical work done by Mr. John Tebbutt at his own observatory, Windsor, New South Wales, claims for him first place on the list of private citizens in Australia who have cultivated astronomy for its own sake.

His first contribution to the store of observed astronomical phenomena dates from 1854. His fame amongst astronomers the world over dates from his discovery of the Great Comet of 1861. His title to the full recognition of valuable service rendered for the credit of Australia and the advancement of astronomical science is based on a lifetime of assiduous and diligent observations of great accuracy and importance, extending over a period of more than half a century. Mr. Tebbutt is now an old man and has practically closed his career as an astronomer, and it seems just to remind Australians that they should lose no opportunity to honour this veteran observer and to show an adequate appreciation of his merits.

Mr. Tebbutt, in his *History and Description of the Windsor Observatory,* written in 1887 (17), and in his later work. *Astronomical Memoirs*, written in 1908 (18), gives a full account of the Windsor Observatory and of the work done by him. from which the information contained in the following notes has been drawn, not infrequently in his own words.

MR. JOHN TEBBUTT'S OBSERVATORY, WINDSOR, NEW SOUTH WALES.

(18) "At the eastern extremity of the municipal town of Windsor, lies the Peninsular Estate, a tract containing about 250 acres of the richest alluvial land. It is so called because it is nearly surrounded by the courses of the Hawkesbury River and its tributary, the South Creek, at their confluence. On a hill situated a little south-west of the middle of the estate, and whose summit is about 50 feet above the mean tide level," stands the residence of Mr. Tebbutt and his observatory, whose geographical position is—

Latitude 33° 36′ 30″ 8 south ;

Longitude 10h. 3m. 20s. 51 east.

Tebbutt's work begins in 1854. He was then 20 years of age. His equipment from 1854 to 1861 consisted of a sextant, artificial horizon, and a "common but excellent eight-day pendulum clock," and a telescope, $1\frac{5}{8}$ inches aperture. He chiefly employed these instruments for self training and "providing gratuitous information of a popular character for the daily newspapers." To these instruments were added a refracting telescope, by Jones, of $3\frac{1}{4}$ inches aperture and 48 inches focal length. in November, 1861 ; and an excellent eight-day half-second box chronometer by Parkinson and Frodsham. in April. 1864. At the close of 1863, a small observatory was erected on the western side of his residence. It consisted of a small wooden building, comprising a transit room and a prime vertical room. An octagonal tower, rising from the centre of the building, served to accommodate the refracting telescope, which he himself mounted in 1864 "according to the

Sisson or old English method." In the same year he installed also a transit instrument with object glass of 2·1 inches aperture, and 20 inches focal length, made for him by Tornaghi of Sydney. The local mean time was determined with this instrument for many years.

All extrameridional observations were made with the $3\frac{1}{4}$-inch telescope till 1872. This was provided with two ring micrometers made by Tornaghi, and eyepieces ranging in magnifying power from 30 to 120.

In 1874, he acquired an equatorial by Cooke and Son, of York, with object glass of $4\frac{1}{2}$ inches aperture and 70 inches focal length, mounted according to Fraunhofer method.

In the same year a circular wooden building, 12 feet in diameter, was erected close to the observatory for the installation of this equatorial.

"In 1879 a substantial observatory of brick was erected on the south-west side of the old buildings," and the equatorial, together with a new transit instrument by Cooke and Son, were permanently mounted on solid masonry piers within the new building.

The object glass of the transit instrument has a clear aperture of 3 inches and a focal length of 35 inches.

Another fine chronometer by John Poole was acquired in 1882.

Finally, in 1887, to the equipment of Mr. Tebbutt's observatory was added a fine equatorial 8 inches aperture and 115 inches focal length, mounted on the Fraunhofer or German plan, and provided with all the usual requisites of a first-class instrument. It was made in 1882 by Grubb, of Dublin.

In the annual reports of his operations, of which he gives a methodical and faithful account from 1864 to 1907, it is shown that his astronomical activities were chiefly directed towards the comets and lunar occultations of stars, but he contributed also, throughout his career, to the study of the phenomena of Jupiter's satellites, the variability of special stars, such as η Argus, R Carinae, and others, and later, with his larger telescope, devoted much energy to micrometric comparisons of the major and minor planets with neighbouring stars and the observation of the more interesting southern binary stars.

His record of work on comets is remarkable. He began with the discovery of the Great Comet of 1861, which caused a sensation, not only on account of its brilliancy, but also because the earth passed through its tail. He observed the return of the celebrated Encke's comet in the following year, and on six other apparitions in the years 1865, 1875, 1878, 1888, 1894, and 1898, and on three or four occasions he was the first to detect it. In 1881 he discovered another comet, which became a fine object as it passed into the Northern Hemisphere, and is specially distinguished by being the first comet of which a satisfactory photograph was obtained and whose spectrum was satisfactorily studied.

Schaeberle's Comet 1881 V. was independently discovered by Tebbutt.

More than 40 other comets, mostly strangers to our system, were observed by Mr. Tebbutt, and followed night after night from the earliest opportunity to the last degree of visibility, determining for each a series of accurate positions, which were employed by him or by other astronomers for the computation of the orbits of these bodies. These observations often extended over several weeks—sometimes months. The comet discovered in America

by Brooks, in 1892, was kept under observation at Windsor on 62 nights; the Coddington Pauly Comet of 1898, for 103 nights; and Halley's Comet, on 21 nights—from December, 1909 to July, 1910. In 1912 he made micrometric measures of Gale's Comet on nine nights.

From 1862 to 1906 he published 35 papers on Comets in the *Monthly Notices of the R.A.S.*; 73 papers in the *A.N.*; 18 in the *Observatory*; 5 in the *B.A.A.*; 2 in *Transactions of the Philosophical Society of New South Wales*.

Such is Mr. Tebbutt's share of Australia's contribution to cometary astronomy.

Next in order on the initial programme of the Windsor Observatory come the Lunar Occultations of Stars. Systematic observations of this class were commenced in 1864 and were continued till 1904, and form part of the regular work of every year of this period, with very few exceptions. Between the years 1896 and 1900, 435 occultations were observed. This will give some idea of Mr. Tebbutt's activity in this branch.

His results of these observations have been widely utilized by astronomers in investigations of longitudes by absolute methods.

Tebbutt's results of occultations observed in the years 1864–1870 were in 1896 employed by Dr. Hugo Clemens, in a determination of the longitude of the Windsor Observatory, and formed the material for an inaugural dissertation entitled *Bestimmung der Länge von Windsor, New South Wales, etc.*

Similar results obtained from observations of the years 1873–1876 were used by Dr. Auwers in conjunction with those observed at Melbourne in 1874 and 1875, for the purpose of obtaining a fundamental meridian for Australia by absolute methods.

The longitude of Windsor, derived from Tebbutt's observations has the following values, viz.:—

Clemens, by observations of occultations, 1864–1870—10h. 3m. 21·25s.
Auwers, by observations of occultations, 1873–1876—10h. 3m. 20·60s.
By telegraphic methods—10h. 3m. 19·87s.

The third item which forms a considerable part of the regular work of the Windsor Observatory, is the systematic observation of the phenomena of Jupiter's satellites.

Records of this work are found in (at least) 25 different years.

"The Windsor observations of jovian eclipses from 1894 to 1899 were employed by Professor J. A. C. Oudemans, of Utrecht, in 1906, in his investigation on the mutual occultations and eclipses of the satellites of Jupiter in 1908."

The record of Mr. Tebbutt's work on variable stars consists chiefly of systematic observations of the well-known southern variables η Argus and R. Carinae.

η Argus was kept under observation every year from 1864 to 1876, and from 1880 to 1890, in which last year, according to Mr. Tebbutt, no further change was detected in its lustre.

R. Carinae was also regularly observed in each year from 1880 to 1890, and also in 1895 and succeeding years till 1898. During the period 1880–1890, ten maxima were recorded.

This series has proved very valuable in the investigation of the secular inequalities of the star.

The Windsor observations of double stars commenced in 1880. After 1887, when the larger instrument (the Grubb 8-inch refractor) was used, special attention was directed to the interesting southern binaries—α Centauri, γ Centauri, and γ Corona Australis, and to difficult southern pairs.

A large amount of other astronomical observations of a miscellaneous character must be credited to Mr. Tebbutt. Among these the more noteworthy are the transit of Venus of 1874, which was successfully observed at Windsor, and several transits of Mercury.

Many Lunar and Solar eclipses were observed by him, and his comparisons of the major planets and a score of the minor planets with neighbouring stars are very valuable.

In 1855, Mr. Francis Abbott, another enthusiastic amateur, was entering the field of observational astronomy in Tasmania. He erected a small observatory at Hobart, and provided it with a portable transit instrument of 24 inches focal length by Varley, and an achromatic telescope of $3\frac{1}{2}$ inches aperture by Cooke and Son, and commenced observations for local time and observations on comets and variable stars. Later he improved his equipment by procuring a larger transit instrument by Dallmeyer, and an excellent telescope of $4\frac{1}{2}$ inches aperture and 5 feet focal length by Dallmeyer, equatorially mounted. These he imported in 1862. A Dollond, 7-feet equatorial came into use soon after.

He was provided with a micrometer, a spectroscope, a standard clock, and a chronometer, and batteries of eye pieces ranging in power from 25 to 450.

He appears to have continued time determinations, for the benefit of himself and of the community, for a number of years, and his observations on comets and on the variable star η Argus are very numerous.

From 1861 to 1874 he contributed about thirteen papers to *Monthly Notices*, which included observations of Comets 1861 II., 1862 II., and 1865 I., this last comet having been discovered by him one day before Moesta discovered it at Santiago (19) (20). Observations of the transit of Mercury of 12th November, 1861 and 4th November, 1868, and many observations of the variable star η Argus.

Criticisms on these latter observations by Herschel, Airy, Lassell, Proctor, and others are published in *Monthly Notices*, Vol. 31 and 32.

He also contributed some twenty papers to the *Proceedings of the R.S. of Tasmania* in the years 1863–1874.

Mr. Abbott died in February, 1883.

Tebbutt and Abbott are the earliest systematic observers in the history of amateur astronomy in Australia.

In this place the name of Ludwig Becker may be recorded as the observer who produced valuable drawings of the Donati Comet, 1858, which he made by means of an equatorial, forming part of the equipment of Neumayer's Magnetic Observatory, at Flagstaff Hill, Melbourne. These fine drawings are published in the *Transactions of the Philosophical Institute* (afterwards the Royal Society) *of Victoria*, Vol. 4, 1859.

The transit of Venus of 1874 gave the opportunity to several amateur observers in various parts of Australia to bring their work into public notice. Among these appear the names of T. D. Smeaton, F. C. Singleton, and

A. W. Dobbie. The first two observed the transit at Adelaide, with small equatorials of $3\frac{1}{2}$ and 3 inches aperture, and the third, with an $8\frac{1}{2}$-inch reflector. *Memoirs R.A.S.*, Vol. 47, 1882–3.

Mr. Dobbie, although his astronomical work was of an occasional character, for many years maintained a keen interest in astronomy. He was one of the observing members of the Mars section of the British Astronomical Association, and constructed his own reflecting telescopes. He completed one 18 inches aperture in 1905.

Two well-known observers who commenced astronomical work in the early seventies are the late Mr. W. J. MacDonnell and Mr. G. D. Hirst.

Mr. MacDonnell was residing at Port Macquarie in 1871. He had an observatory there equipped with a 6-inch achromatic equatorial by Grubb, of Dublin, with which he made observations for a few years. Later he moved to Sydney, where, up to the time of his death, on 22nd September, 1910, he assiduously continued his astronomical observations with a $4\frac{3}{4}$-inch achromatic telescope by Parkes, of Birmingham, an excellent instrument, equatorially mounted and driven by clock work.

He observed the transit of Venus of 1874, as a member of one of the official parties stationed at Eden, under the Rev. Mr. Scott, once Director of the Sydney Observatory.

He was one of the observers of the Jupiter section of the British Astronomical Association up to the time of his death, and contributed several papers and notes to the *Journal* and *Memoirs* of that association, on Jupiter, on Halley's Comet, occultations and other subjects of a more general astronomical interest.

Mr. G. D. Hirst, of Sydney, is noted for his remarkable skill in astronomical drawings. He has been a member of the observing sections of Jupiter and Mars of the British Astronomical Association, and several of his beautiful drawings of these planets have been reproduced in the *Memoirs* of the Association.

The Director of the Mars observing section—M. Antoniadi, referring in one of his reports to the work of Mr. Hirst, says "The drawings of Mr. Hirst are coloured and represent the general appearance of the Planet (Mars) more faithfully than any others received during the apparition." (1905) *Memoirs B.A.A.*, Vol. XVII., Part II.

Mr. Hirst used an achromatic telescope by Cooke, equatorially mounted, object glass $4\frac{1}{4}$-inch aperture.

His work extends over a period of 40 years, and includes, in addition to studies of surface detail of Jupiter and Mars at several oppositions, observations of comets and double stars, the results of which, or of most of them, have been published in the *Journal and Memoirs of the B.A.A.* and in the *Journal and Proceedings of the R.S. of New South Wales*, to which societies he has contributed also various papers and notes on other subjects.

Among the private citizens interested in Australian astronomy not previously mentioned, whose contributions to it, or valuable services rendered to, in the period 1880–1890, should be placed on record, are the following:—

In Tasmania, A. B. Biggs; in Victoria, Dr. Bone, David Ross, James Oddie; In Queensland, J. E. Davidson; In New South Wales H. F. Madsen, H. Watt, and H. Corbett.

The late Mr. Biggs was a judicious and ingenious observer, and some of his observing instruments and apparatus were made by himself. On the occasion of the transit of Venus of 1874, the assistance of Mr. Biggs was very highly appreciated by the observing party from the United States, at Campbelltown, in overcoming instrumental difficulties. The principal instrument with which he made his observations, especially in the years of his greater activity—1883-1887—was a reflecting telescope with mirror 8½ inches diameter.

He employed also a refractor of 3-inch aperture, and was provided with a sidereal clock, a chronometer, a small direct vision spectroscope by Browning, and other minor apparatus.

His subjects of observation were chiefly comets. The results of his work were published in the *Monthly Notices of the R.A.S.*, Vol. 45, pp. 348 and 376.

He also contributed thirteen papers, bearing on astronomy, to the *Proceedings of the R.S. of Tasmania*, from 1884 to 1891.

The late Dr. Bone built a private observatory on his grounds at Castlemaine, Victoria, where in 1881 he installed an equatorial telescope with achromatic object glass 8-inch aperture, by Grubb, of Dublin, an excellent instrument, provided with all requisites for fine astronomical work. He had this instrument mounted and in working order just in time for the transit of Venus of 1882, which he observed successfully. He had planned a useful programme of work for himself, which, however, was not to be carried out, for he died very shortly after.

But his telescope was destined to do good work for many years after him, in the hands of Mr. John Tebbutt, at the Windsor Observatory, by whom the instrument was bought.

Mr. David Ross, of Melbourne, in 1883, while watching the heavens for the expected periodical comet of Pons, discovered a small southern comet (1883 II.) His instrument was a small portable 3-inch achromatic telescope mounted on a short tripod. Later he constructed for himself a 6-inch reflecting telescope of the Newtonian type, which he mounted equatorially. He has employed it systematically during all these years, chiefly searching for comets; and in 1906, he made his second discovery of Comet 1906 II.

In 1887, Mr. James Oddie had erected at his own cost an observatory at Mount Pleasant, Ballarat, Victoria, which he equipped with various apparatus, chiefly reflecting telescopes locally constructed.

He engaged the services of the late Captain Baker, who at the time had become favorably known for his skill in making parabolic reflectors, and placed him in charge of the observatory.

A mirror 26 inches in diameter was completed by Captain Baker in 1891, which was mounted equatorially as a Newtonian telescope driven by clockwork. Another 12-inch Newtonian telescope was also mounted.

The observatory was provided with a small transit telescope, astronomical clock, and accessories.

The instruments were well housed in spacious wooden buildings which contained in addition to other apartments, a large lecture room.

In 1888, Mr. Oddie imported an excellent equatorial telescope with object glass 9 inches clear aperture and 135 inches focal length by Grubb, of Dublin, which, however, was never taken out of its packing cases.

This is the instrument which, in 1910, was presented by Mr. Oddie to the Commonwealth Government and subsequently erected at the Mount Stromlo Observatory in the Federal territory.

Mr. Oddie's observatory at Mount Pleasant, was chiefly intended for the education and entertainment of the public of Ballarat, and no astronomical work of a systematic character was ever done there. The observatory was dismantled in 1910.

On 21st July, 1889, Mr. J. Ewen Davidson, of Mackay, Queensland, made the discovery of Comet 1889 IV. by means of one of the telescopes used by the British Expedition under Captain Morris, R.E., for the observation of the transit of Venus, in December, 1882, at Jimbour, Queensland, and sold afterwards to Mr. Norris, of Townsville.

Several amateur makers of reflecting telescopes were very active during this decade, and contributed considerably to foster astronomical interest. These are—

R. W. Wigmore and R. Shafer, of Melbourne: Dobbie, of Adelaide; H. Watt, H. Corbett, Walter Gale, who commenced constructing his own telescopes in 1882 when he was still a school boy, and H. F. Madsen, of New South Wales: and others less well known.

Mr. H. F. Madsen's paper in the *Proceedings of the Royal Society of New South Wales*, upon the construction of a reflecting telescope of 18 inches aperture is a valuable contribution to the subject.

In later years, and up to the present time, we find the number of amateur observers and persons interested in the advancement of Australian astronomy gradually and widely increasing, and there are among them several names which have gained distinction through the value of their work.

Messrs. R. T. A. Innes and C. J. Merfield were at one time serving enthusiastically in the ranks of amateur astronomers in New South Wales—Innes till 1896, when he left Australia to take up an official position under Dr. Gill, at the Cape Observatory; and Merfield, till 1905, when he joined the Sydney Observatory. The work of these men, which was done in their amateur days, should be noted here.

Innes used a refractor of 6½-inch aperture, and a Newtonian reflector, with a mirror of 16 inches diameter, and carried on observations of variable stars and double stars; some of his results were published in the *Monthly Notices of the R.A.S.* and in the *Journal of the British Astronomical Association*. List of probable new double stars, and Occultation of Antares, 1894, 31st October, *Monthly Notices*, Vol. 55; on the proper motion of Lacaille, 4336, *Monthly Notices*, Vol. 56; new double stars, *Journal of the British Astronomical Association*, Vol. 6; observations made at Sydney in 1895; and observations of variable stars, 1895–96; and order of brightness of the 1st magnitude stars, *Journal of the British Astronomical Association*, Vol. 6, etc.

Innes contributed also papers on the secular perturbations of the Earth's orbit by Mars, *Monthly Notices*, Vol. 52; the secular perturbations of the Earth arising from the action of Venus, *Monthly Notices*, Vol. 53; elements of Comet 1894 (Gale, 1st April), *A.N.* 3231; Table to facilitate the application of Gauss's method of computing secular perturbations, *Monthly Notices of the R.A.S.*, Vol. 154, and other writings.

Merfield employed a refractor of $6\frac{1}{4}$-inch aperture by Cooke, equatorially mounted; a reflector, equatorially mounted, mirror 7 inches diameter; a small transit circle, with object glass $2\frac{1}{4}$ inches aperture; chronometers; and a tape chronograph.

With this equipment he conducted systematic observations for several years, chiefly on coloured stars and comets.

Most of the astronomical data for the use of observers in New South Wales on special events, such as predictions of occultations, elements and ephemeris of newly discovered comets, ephemeris of expected periodical comets, times and explanatory notes of eclipses of the sun and of the moon, and other celestial phenomena of public interest were prepared very frequently by Innes, and later, from 1894 to 1905, very regularly and almost entirely by Merfield.

Gravitational astronomy was, however, the work in which Merfield was particularly interested, and to which he devoted most of the time he could spare from his ordinary daily occupation.

Amongst the most important of his papers on this and allied subjects, the following may be mentioned:—Definitive orbit elements of comet 1898 VII.; Definitive orbit elements of comet 1899 I.; Definitive orbit elements of comet 1901 I.; Secular perturbations of Eros arising from the actions of the eight major planets of the solar system; Determination of the secular perturbations of minor planet Ceres, arising from the actions of the eight major planets of the solar system; Secular perturbations of (7) Iris, arising from the actions of the eight major planets of the solar system; Secular perturbations of Ceres, arising from the action of Jupiter (with an important appendix on the co-efficients of the hyper-geometrical series F $\alpha\, \beta\, \gamma\, \chi$). Tables of the two hypergeometrical functions—F ($\frac{1}{6}$, $\frac{7}{6}$, 2, $\sin^2 \frac{1}{2}$), and F ($-\frac{1}{6}$, $\frac{7}{6}$, 2, $\sin^2 \frac{1}{2}$).

Walter F. Gale, one of the best known and most skilful observers of New South Wales, had been devoted to astronomical observations and the making of reflecting telescopes since 1882, but it was not till ten years later that he became possessed of a sufficiently suitable equipment for systematic work. In 1892, by means of an exquisitely defining reflecting telescope by With, of $8\frac{1}{2}$ inches aperture, he made many observations, particularly of the planet Mars, which, with four drawings, were published in the *Journal and Memoirs of the British Astronomical Association*. This observer was the first, it appears, to note the delicate markings now known as the "oases" of Mars, as recorded by Flammarion and Antoniadi. In 1893 he observed the total eclipse of the sun at Mina Bronces, in Chile, and has since "chased" three other solar eclipses, but each time met with adverse weather conditions.

He also devoted much attention to Jupiter and his Galilean satellites, several hundreds of observations of which are published in the *Memoirs of the B.A.A.*

Mr. Gale has independently discovered six comets, two of which bear his name, namely:—Gale 1894 II., and Gale 1912 *a*.

Comet 1888 I., Sawerthal, was found by him independently only one day after Sawerthal had discovered it at the Cape, and the other three comets proved to be returns of periodical comets—Fabry 1886 I., Winnecke 1892 IV., and Tempel[2] 1894.

He also discovered several double stars and a ring nebula.

Notes upon these discoveries were published in the *Astronomische Nachrichten*, in the *Monthly Notices of the R.A.S.*, and other journals.

Perhaps the best service rendered to Australian astronomy by Mr. Gale was the part he took in conjunction with Innes in forming the New South Wales branch of the British Astronomical Association.

This branch was constituted in September, 1894, when it consisted of thirteen members, namely:—John Tebbutt, R. T. A. Innes, W. F. Gale, G. H. Knibbs, C. J. Merfield, H. Wright, G. Butterfield, C. Mathews, F. D. Edmonds, R. D. Lewers, J. W. Askew, T. W. Craven, and C. C. Carter. It made rapid progress and its roll of members gradually increased.

In 1895, a special section for the observation of coloured stars was first formed, with Merfield as director and two observers, namely—H. Wright, who employed a reflecting telescope of $8\frac{1}{2}$ inches aperture; and F. K. McDonall, with a $2\frac{1}{8}$-in. refractor; Merfield himself using a 7-in. reflector. Upwards of 5,000 observations were made of 458 stars in accordance with a carefully planned programme, which was completed in the years 1895–97. The results of this work are published in Vol. VI., No. 9, and Vol. VIII., No. 1 of the *Journal B.A.A.*

In 1897 special observing sections were formed as follow:—Comet section—Director, John Tebbutt; Jupiter section—Director, W. F. Gale; Sun and Meteors—Director, F. K. McDonall.

The first president of the branch was Mr. John Tebbutt, in which office he was followed by G. H. Knibbs, the present Commonwealth Statistician, who in the year 1900 prepared a paper on "The Sun's motion in Space," which was published in the *Proceedings of the R.S. of New South Wales*, Vol. XXXIV. It contains the history and bibliography of the subject from Giordano Bruno (1584) to Kobold (1900), and is qualified by the author as a step preliminary to a further consideration of the whole question, which however, his subsequent official duties prevented him from carrying out.

The paper, which bears clear evidence of a vast amount of careful research renders a complete account of the state of knowledge on the subject existing up to the year 1900, and forms an astronomical contribution of great value.

The third president (Session 1899–1900) was the Rev. Dr. Roseby, a fluent writer on astronomical subjects, and more particularly interested in gravitational astronomy. The elliptic elements of Gale Comet 1894 *b*, were computed by him.

Subsequent occupants of the chair were W. F. Gale, W. J. MacDonnell, G. D. Hirst, and C. J. Merfield, whose work has already been separately referred to, and next to these come H. Wright (1907–1909), J. Nangle (1909–1911), and again the Rev. Dr. Roseby (1911–1913).

Mr. H. Wright has for a long time been devoted to astronomical observations, for which he uses a reflecting telescope of the Newtonian type, by Browning, $8\frac{1}{2}$ inches aperture equatorially mounted. Amongst the papers published in the *Journal* of the Association, containing the results of his work are the following:—

Double star observations and observations of meteors, Vol. VI.;
Daylight occultation of Antares, Vol. VII.;
Chamber's catalogue of red stars, Vol. XI.;
Some southern nebulæ and the trapezium of Orion, Vol. XII.; comet Moorehouse 1908 *c*, Vol. XIX.

He is a member of the "Jupiter" and "Mars" observing sections, and a number of his drawings and observations of these planets, also of Saturn and Halley's Comet, have been published in the *Memoirs of the B.A.A.* At one opposition of Mars there were only three southern observers, and his contribution carried considerable value and was highly appreciated. He has observed and sketched sun spots and solar prominences, and published several papers on astronomical subjects of a more general interest.

James Nangle is another practical observer of considerable merit and the possessor of a first-class achromatic telescope, by Cooke and Sons, of 6½-in. aperture, mounted equatorially and driven by clockwork, which had been used by Innes when a resident of Sydney.

The instrument is housed in a well-built and commodious observatory, where work is being done with efficiency and comfort.

The nature of his observations and the subjects in which he is more particularly interested are shown by his published results in the *Journal* of the Association, some of which I note here.

Double star measures, Vols. XVII. and XXI.
Measures of α Centauri, Vol. XIX.;
Measures of ρ Eridani, Lacaille 2145, Vols. XIX. and XX.;
Provisional orbits of ρ Eridani and h 5014, Vols. XIX.; and XXI.;
Orbit of B Muscae, Vol. XX.;
Cluster about K Crucis, Vols. XIX. and XVIII.;
Saturn's diameter, Vol. XVIII.;
Occultations of θ Libræ and Uranus, Vol. XVIII.

The New South Wales branch of the B.A.A. is still in full working activity. Of the total number of 76 Australian members of the parent association, more than one half belong to this branch.

Mr. E. H. Beattie, the present secretary, is also a contributor to the advancement of Australian amateur astronomy. He has a good observatory, equipped with an excellent equatorial refractor by Grubb, 6¼ inches aperture, driven by clockwork, and provided with all the accessories required for micrometric measurements. His principal observations are—occultation phenomena of Jupiter's satellites, double stars, comets, eclipses and occultations of stars and planets by the moon.

The results of his work, as well as his reports of work done by the branch generally, to the parent association have been and are being regularly published in the *Journal of the B.A.A.*

Mr. T. H. Close renders good service by computing comets' orbits and lunar occultations by graphical methods, and furnishing such data to those interested.

Other members of this branch figure in the *Journal and Memoirs* of the Association as members of some particular observing section, and as contributors of astronomical papers, notes, or drawings. These are J. E. Bell (Solar Section), H. Brown (Comet Halley), R. H. Bulkeley (Comet Halley), A. B. Cobham (Jupiter and Mars), the late Dr. R. D. Givin (Jupiter, Mars, and the Sun), G. H. Hoskins (Mars), J. C. Jenkinson (Auroral and Zodiacal light), F. K. McDonall (Meteors), D. Shearer (Mars), Rev. W. Swindlehurst, P. Chauleur, Captain Edmonds, and Mr. N. J. Basnett, who specializes in meridian observations for the accurate determination of time.

For the published results of the above observers, see list in Appendix.

In 1897, a branch of the British Astronomical Association was formed in Victoria, and the attempt was made to encourage the possessors of astronomical telescopes to undertake systematic observations with them. The principal names of those who worked energetically in organizing and afterwards struggling to set the branch in working order are those of—

R. W. Wigmore, the late Professor Kernot, Dr. E. F. J. Love, C. Oliver, M.C.E., T. W. Fowler, M.C.E., Professor Barnard, Mrs. Rose Whiting, David Ross, and George Smale.

The inaugural meeting of the branch took place on the 16th December, 1897, under the presidency of the late R. L. J. Ellery, who held office till the year 1900, the chair being successively occupied after him by the Rev. John Meiklejohn, Dr. Love, Professor Kernot, and Professor Barnard.

R. W. Wigmore was secretary for the period (1897–1900), David Ross (1900–1901), and George Smale (1901–1905).

The difficulty which prevented the sound development of this branch and eventually caused its extinction at the end of 1905, was the failure to induce a sufficient number of its members to use their telescopes for some definite astronomical purpose, and in accordance with a suitably prep red plan.

Professor Barnard has been for many years interested in the observation of variable stars. He is at present in charge of a small observatory recently erected at the Royal Military College of the Commonwealth, on the summit of Mount Pleasant, near the Federal capital site.

The observatory is provided with an equatorial refractor, by Cooke and Sons, of 4½ inches aperture, and a portable transit instrument, and it is expected that Professor Barnard will be able to continue there regular observations on variable stars.

The object of this observatory is principally educational.

There is only one other State of the Commonwealth at present in which an Astronomical Society exists. This is South Australia.

The Astronomical Society of South Australia is intimately associated with the Adelaide Observatory. Until the end of 1906, it held its meetings at the Observatory, and although at present the members meet in another building, the Observatory instruments are still at their disposal, and in fact, the present director states "the observations of variable and double stars have now been commenced by certain members of the local Astronomical Society, the equatorial telescope of the Observatory being used for this purpose."

This society dates back to the year 1892, when as a section of the Royal Society of South Australia, it held its first meeting at the Adelaide Observatory, on the 5th April of that year, under the presidency of the late Sir Charles Todd.

The annual reports of the society show a considerable number of persons (40 or more) who have at some period been interested in astronomy, and among them there are several whose writings on astronomical subjects appear in the *Transactions* of the society. (For the principal titles and references to these works, see Appendix B.) It does not appear, however, that astronomical observations of a systematic character have been made by any observer in South Australia for the object of carrying out a continuous and well-

defined astronomical programme, though Mr. Sydney Manning, of McLaren Vale, has contributed observational notes on comets and the Kappa Crucis cluster to the *Journal of the B.A.A.*

There are no records of astronomical results obtained by amateur astronomers in Queensland and Western Australia, with the exception of those registered in the papers given in the Appendix.

(d) Australian Expeditions on Special Astronomical Occasions.

There were five occasions upon which the official astronomers of Australia recognised it as their duty to organize astronomical expeditions for observing important astronomical phenomena at places remote from their permanent observatories.

These occasions are—

1. The total eclipse of the sun of December, 1871—at Eclipse Island, off the extreme north of Australia ;
2. The transit of Venus of December, 1874 ;
3. The transit of Venus of December, 1882 ;
4. The total eclipse of the sun of May, 1910—at Bruni Island, in the South Pacific ;
5. The total eclipse of the sun of April, 1911—at Vavau (Friendly Island).

1. This eclipse occurred on the 11th December, 1871. The path of totality crossed the Gulf of Carpentaria, touching Australia near its extreme northern points.

The proposal to fit out an expedition to observe the eclipse was made by the late Professor Wilson, and, on the recommendation of the Royal Society of Victoria, the Governments of Victoria and New South Wales authorized their respective astronomers—R. L. J. Ellery and H. C. Russell—to organize a party of observers suitably equipped for the purpose.

The locality selected for observation was a small island off the north coast, called, since, Eclipse Island. The Queensland Government provided the, then new, steamer *Governor Blackall* to carry the expedition to its destination and back.

The party consisted of the principal assistants of the Melbourne and Sydney Observatories and a large number of other observers recruited amongst the most eligible in the colonies.

The expedition was provided with the 7¼-in. equatorial, by Merz, of the Sydney Observatory, upon which was mounted a camera with lens of 3 inches aperture and 30 inches focal length ; the 4½-in. equatorial of the Melbourne Observatory, and several other smaller equatorial telescopes, all driven by clockwork ; photographic and spectroscopic apparatus fitted for the purpose. Special instruments, adapted for the occasion, had been forwarded by the Eclipse Committee of the British Association for the service of the expedition.

The expedition started from Sydney on 27th November, 1871, reached Eclipse Island on 7th December, and had the instruments ready by the 10th December, the day before the eclipse. On the 11th, unfavorable weather prevailed, and the sky was overcast during the whole time of totality.

Thus the expedition failed in its main object.

2. For the observation of the transit of Venus, in 1874, the official astronomers of the time—Ellery, Russell, and Todd—organized various parties, which were sent to occupy favorable spots in their own respective colonies.

In the colony of Victoria, Ellery selected, in addition to the Melbourne Observatory, where he himself and his assistants observed the transit, three subsidiary stations. These were—

Mornington, on the shores of Port Phillip Bay, and about 30 miles south of Melbourne;

View Hill, Sandhurst, 86 miles north-west of Melbourne;

Glenrowan, 150 miles north-east of Melbourne.

The observations at the Melbourne Observatory were directed by Ellery using the 8-in. equatorial, an 18-in. altazimuth, the Grubb 4-ft. reflector, and Dallmeyer's 4-in. photoheliograph. Good observations of internal contact at "Ingress" and "Egress" were obtained. Many micrometric measurements of diameter of Venus were made by a double image micrometer, and physical phenomena well observed. Several photographs were secured, both with the photo-heliograph and the great telescope.

The party at Mornington was in charge of Professor Wilson, of the Melbourne University; its equipment consisted of a $4\frac{1}{2}$-in. equatorial, by Troughton and Simms, with which micrometric measurements and contact observations were made; fair results of "Ingress" and "Egress" phenomena were obtained.

At View Hill, Sandhurst, Mr. C. Moerlin (assistant of the Melbourne Observatory) directed the operations. The instrument employed was an equatorially-mounted telescope, with objective $6\frac{3}{4}$-in. aperture, by Ertel, of Munich, provided with a double image micrometer. Cloudy weather prevented contact observations at "Ingress," but some satisfactory results of "Egress" phenomena were obtained.

At Glenrowan, the party was in charge of Messrs. A. C. Allan and James Gilbert. The instruments employed were a $4\frac{1}{2}$-in. equatorial, by Cooke and Sons, and a reflecting telescope, by Browning, $8\frac{1}{2}$-in. aperture, equatorially mounted. Observations of "Ingress" were made satisfactorily in clear weather, except the first external contact, but no observations of "Egress" could be made, the sky being overcast.

In New South Wales, Russell, with the aid of the local Royal Society, was able to obtain sufficient encouragement and assistance from his Government to carry out the extensive preparations which he had planned with the object of securing observations on the eventful day of 9th December, 1874, at four different places in his colony. (6)

These were—

The Sydney Observatory;

Eden, on the north shore of Twofold Bay, 350 miles south-west of Sydney;

Goulburn, 134 miles south-west of Sydney, 2,071 feet above sea level;

Woodford, in the mountainous district, 50 miles west of Sydney.

Parties were despatched to these places equipped with equatorially-mounted telescopes, fitted with apparatus for photographing the sun, and provided with means for determining time, material for obtaining upward of 200 pictures of the sun, observing huts, and all necessary appliances.

(21) At Sydney, the observers were directed by Russell: the instruments employed were the 11·4-in. equatorial, by Schroeder, fitted with photographic apparatus, which could be quickly removed and mounted again; a $4\frac{3}{4}$-in. equatorial, by Troughton and Simms; and a 10-in. Browning silvered glass reflector.

At Eden, the Rev. W. Scott conducted the work: the instruments used were a $7\frac{1}{4}$-in. equatorial, and two other smaller achromatic telescopes, with objectives $4\frac{1}{4}$ inches and $3\frac{1}{2}$ inches aperture respectively.

The station at Goulburn was occupied by Captain Hixson: this party was provided with an achromatic telescope of 6 inches aperture, equatorially mounted and fitted with a camera; also two smaller equatorial refractors of $3\frac{3}{4}$ inches and $3\frac{1}{4}$ inches aperture.

At Woodford, the observing party was in charge of Surveyor-General Adams. The observations were made with $3\frac{1}{2}$-in. equatorial, and a 4-in. photoheliograph was employed for obtaining pictures of the sun. This station, in addition to the provisions made as at the other three places for taking 220 pictures, had a supply of 30 Janssen plates, each to hold 60 pictures.

Mr. Tebbutt observed the transit independently at his observatory, Windsor, with a $4\frac{1}{2}$-in. equatorial. He had fine weather, and obtained accurate times of the beginning and end of the transit. (18)

In South Australia the transit was observed—

By Mr. Todd, at the Adelaide Observatory, the instruments used being the 8-in. equatorial, by T. Cooke and Sons, and a camera arranged to give an enlarged picture of the sun.

By T. D. Smeaton, J.P., at his residence, North Adelaide, using an excellent $3\frac{1}{2}$-inch equatorial by Cooke and Son.

By F. C. Singleton, on the grounds of the Adelaide Observatory, using a 3-in. equatorial.

By A. W. Dobbie, at his residence, 2 miles north-east of the Adelaide Observatory, using an $8\frac{1}{2}$-in. silvered glass reflecting telescope.

The weather was unfavorable at Adelaide up to a short time after "Ingress" and was only intermittently clear afterwards.

Todd obtained a few micrometric measurements, and made some observations of the approach of internal contact at "Egress."

Messrs. Smeaton, Singleton, and Dobbie were able to observe and record the times of internal and external contact at "Egress."

On the whole, Australia acquitted itself with credit on the occasion of the transit of Venus of 1874, and the Australian results form an important part in the investigation of the solar parallax, based on the observations of this transit.

3. The Australians had no opportunity of observing the complete set of phenomena of the transit of Venus of 7th December, 1882, as the beginning of the transit took place before sunrise. The importance of securing observations of the other phases was, however, fully understood, and extensive preparations were made accordingly.

In Victoria, Ellery sent out two parties from the Melbourne Observatory —one to Hobart, and one to Sale, Gippsland—Ellery himself remaining stationed at the Observatory in Melbourne.

The instruments employed at these three stations were the same as those with which observations of the previous transit had been made.

Ellery and White had fine weather and obtained good results.

The weather in Gippsland was unfavorable, and no observations of any part of the transit were made.

In New South Wales, Russell organized, equipped, and trained five expeditions, which he was able to supply in each case with two equatorially-mounted telescopes of 6-inch and 4½-inch aperture. Fifteen observers took part in the work. The five stations occupied by these parties were Port Macquarie, Clarence River, Dromedary, Katoomba, and Lord Howe Island. Russell and his staff were stationed at the Sydney Observatory.

None of these parties were successful, owing to adverse weather conditions.

Tebbutt, at the Windsor Observatory, met with similar ill fortune. Thus no contribution was made by New South Wales observers upon the transit of Venus of December, 1882.

The Government Astronomer of South Australia—Mr. Todd—observed the transit at Wentworth with a 4½-inch equatorial. He met with fine weather, and his programme of observations was successfully carried out. (15)

4. The southern parts of Tasmania and Bruni Island were the only localities from which the total eclipse of the sun of 9th May, 1910, could be seen. The chance of successfully observing this eclipse was very small on account of the low altitude of the sun at the time of totality, and of the unfavorable and severe weather conditions generally prevailing in these particular localities so late in the autumn. It was known that, owing probably to this uncertainty and to the great length of the journey involved, no official expedition was to be despatched to Tasmania on this occasion, and only one private party, conducted by Mr. Frank McClean, was expected to come out in due course to occupy some spot within the belt of totality.

Under the circumstances it was clearly the duty of Australian astronomers to deal with the Tasmanian eclipse.

Dr. W. G. Duffield, of South Australia, now Professor of Natural Philosophy at the University College of Reading, brought this matter before the Council of the Australasian Association for the Advancement of Science at its Brisbane meeting, of January, 1909, and that Council appointed a committee, with Dr. Duffield as secretary, for the purpose of taking steps to ensure that efficient preparations were made to observe the eclipse in question. The result was that the Government of Victoria provided its own astronomer with the required means for organizing and fitting out an eclipse expedition to Bruni Island, which was done.

The Joint Permanent Eclipse Committee of the Royal Society and Royal Astronomical Society supplied a part of the equipment to this expedition.

Unfortunately it is needless to detail the elaborate preparations made since the day remained completely overcast, and nothing was seen of the eclipse, except a general darkening of the landscape.

Mr. Frank McClean and his party, who were stationed at Port Davey, some 60 miles to the west of us, and Mr. Walter Gale, of Sydney, who had purposely gone to Hobart on his own initiative to observe the eclipse from a position in that city, were also unable to see the eclipse owing to cloud and rain.

5. At the Sydney meeting of the Australasian Association for the Advancement of Science, in January, 1911, the same Eclipse Committee was re-appointed with the object of forming an Australian expedition for the observation of the total eclipse of the sun of 29th April, 1911, at Vavau, one of the islands of the Tonga Group in the Pacific Ocean. Dr. Duffield being in Europe, Professor Moors, of the Sydney University, was appointed secretary to the committee.

The committee, having succeeded in obtaining a subsidy of £500 from the Commonwealth, was able to organize and equip a party.

The equipment of the expedition comprised principally—

- 4-inch photoheliograph (Melbourne Observatory);
- 4½-inch equatorial telescope (Melbourne Observatory), with two large portrait lens cameras attached;
- One coronograph (Perth Observatory);
- One coronograph (Adelaide Observatory);
- One 16-inch coelostat, lent by the British Eclipse Committee;
- One 12-inch coelostat, lent by the British Eclipse Committee;
- One coronograph (Sydney University);
- One 6-inch refracting telescope, with camera attached;
- One smaller equatorial;
- A large altazimuth, for time determination (Perth Observatory);
- Also several cameras of various sizes, chronometers, subsidiary apparatus, observing sheds and huts, living tents, and camp material.

On the morning of the eclipse all instruments were in good order and adjustment and the observers had been thoroughly drilled.

The weather was unpromising, and the face of the sun was obscured intermittently by passing clouds up to the beginning, and during a considerable part, of the phase of totality. Each observer, however, accomplished his allotted programme, and some 45 plates were exposed during the three and a half minutes of totality. The plates were developed the same evening, and the results obtained were found to be much better than was at first expected.

The form of the corona was found to correspond to the type which had been observed on several previous years of minimum solar spots.

Although this single result brings no new knowledge of eclipse phenomena, yet, taken as additional evidence concerning an important characteristic of the solar corona which is obtainable only on relatively rare occasions, it becomes a valuable contribution to the store of eclipse records.

(e) Determinations of Australian Longitudes.

Until the year 1883 the adopted fundamental meridians of Australia were those of the Observatories of Sydney and Melbourne, and the longitude assigned to these meridians depended on the observation of "moon culminations" and "moon culminating stars."

Until these two Observatories came into existence, the fundamental meridian of Australia was that which passes through Fort Macquarie, on one of the picturesque headlands of Sydney Harbor.

The longitude of this meridian was derived chiefly from the lunar observations of the early navigators, from Captain Cook in 1770 to Admiral King in 1817, and, later, to Sir Thomas Brisbane, Rumker, and others; the results of these observers fluctuated over a wide range which, however, is quite compatible with the conditions of the time.

Fort Macquarie was one of the points on the longitude circuit measured all round the globe by transportation of chronometers during Captain Fitzroy's famous voyage in H.M.S. *Beagle* in 1831–36. The longitude found for Fort Macquarie was 10h. 4m. 32.14s., and if the correction 0s. 115t = + 20.52s. as proposed by Dr. Auwers (22) be applied to it, it becomes 10.4.52.66, which is only 0.75s. in excess of what may be considered the most probable value of the longitude of this point at the present day.

The meridian of Fort Macquarie remained for many years the basis from which explorers and surveyors established geographical positions inland and originally ascertained the meridional subdivisions of the Australian Colonies geodetically or by transportation of chronometers.

One of the earliest and most interesting undertakings of this kind was the definition of the 141st meridian of east longitude, which was proclaimed as the eastern boundary of the Colony of South Australia by an Act of King William IV. in 1834.

In 1839, owing to the discrepant positions assigned to this meridian on different maps of the time, Mr. Surveyor C. J. Tyers was commissioned by Sir George Gipps, Governor of New South Wales, to ascertain its true place.

Tyers, adopting as his base the longitude of Fort Macquarie as 151° 15′ 14″ = 10h. 5m. 0·93s., determined the longitude of a point on Batman's Hill, near Melbourne, by transportation of chronometers, and thence by triangulation with a small theodolite fixed the position of the 141st meridian, which he verified by sextant observations of lunar distances.

Captain Owen Stanley recalculated Tyers' work, and the result he arrived at differed by only 16·2″ from that of Tyers.

Tyers, having adopted a longitude base, which, according to more modern determinations, was more than 2 miles in error, and having carried out his own work with all the accuracy which was possible under the circumstances, the consequence was that the boundary was fixed, and afterwards (in 1847) actually marked on the ground more than 2 miles to the west of the 141st meridian east of Greenwich.

The longitude of the Parramatta Observatory was determined by Rumker by transit observations of the moon and moon culminating stars. Its value is given in the Philosophical Transactions for 1829 as 10h. 4m. 6·25s.

In *M.N. of the R.A.S.*, Vol. VI., page 213, Rumker, rediscussing his Parramatta observations, gives as a corrected value of this longitude 10h. 4m. 7·217s.

The first value of the longitude of the Sydney Observatory was obtained by the Rev. W. Scott in 1858, and was derived from the observations of 21 transits of the moon. The result was 10h. 4m. 49·0s.

In 1859 Mr. Scott observed 38 moon culminations which gave as the resulting longitude of the Sydney Observatory 10h. 4m. 59·86s. (23)

Similar observations, 50 in 1860, and 56 in 1861, furnished the value 10h. 5m. 6·84s. (25)

Stone, from a rediscussion of Scott's moon culminations. observed at Sydney in the years 1859 and 1860, obtained longitude of Sydney Observatory 10h. 4m. 47·32s. (24)

In 1861 the first determination was made of the difference of longitude between the Observatories of Sydney and Williamstown by the telegraphic exchange of clock signals, and the value obtained was Sydney-Williamstown 0h. 24m. 55·38s. (26)

The longitude of the Williamstown Observatory was determined by the observations of moon culminations in the years 1860, 1861, and 1862, the adopted result being 9h. 39m. 38·8s. E. (11)

The difference of longitude between the Williamstown and the Melbourne Observatories was found by accurate triangulation to be 16·00s., giving for the longitude of the Melbourne Observatory 9h. 39m. 54·8s. (27)

This value was adopted and used until the year 1883.

In 1867 the difference of longitude between the Observatories of Melbourne and Adelaide was measured by telegraphic exchange of clock signals, giving the result 0h.25m.33.76s., which, being applied to the longitude of Melbourne, gave longitude of Adelaide Observatory 9h.14.21m., which value was adopted, and remained unaltered till 1883. (28)

Soon after the longitudes of the Sydney and Melbourne Observatories had been determined from lunar observations, it became evident that the longitude of the earlier fundamental meridian of Fort Macquarie, adopted by Tyers, was considerably too great, and that, consequently, the boundary between the Colonies of Victoria and South Australia had, very probably, been marked too far west, and the error was further verified by the results of the trigonometrical survey of Victoria, which connected the Melbourne Observatory with a western station of the survey near the South Australian boundary.

It thus became an important matter to ascertain the position of the 141st meridian by a fresh determination, and the Governments concerned ordered the work to be done by the Government Astronomers of the respective States.

The plan adopted by Todd, Ellery, and Smalley was to determine the difference of longitude by the exchange of time signals by telegraph between a temporary Observatory, erected for the purpose, near the northern end of the marked boundary, and the Observatories of Sydney and Melbourne. Todd occupied the station at the boundary, using the transit instrument by Troughton and Simms, of 3½-in. aperture, which had been used at Adelaide. Smalley operated at the Sydney Observatory, and Chief Assistant White at Melbourne Observatory.

On 9th May and 10th May the transits of ten stars. over the meridian of the Observatories at Sydney and at the boundary, were recorded simultaneously at both stations, and on 13th and 14th May the transits of 21 stars were similarly recorded at the boundary and at Melbourne Observatory. Exchange of time signals was effected also between the two Observatories of Melbourne and Sydney.

The results were as follow :—

	h.	m.	s.
Difference of longitude—			
Boundary-Sydney	0	40	59·72
Boundary-Melbourne	0	16	3·77
Melbourne-Sydney	0	24	55·81
The adopted longitude for Melbourne was ..	9	39	54·80
The adopted longitude for Sydney was	10	4	48·97

The adopted longitude for Sydney was the mean of the value 10h. 4m. 47·32s. calculated by Stone from Scott's lunar observations of 1859 and 1860 (24), and the value found by applying the difference Sydney-Melbourne 0h. 24m. 55·81s. to the longitude of Melbourne Observatory 9h. 39m. 54·8s.

From these data, and the measurement, by chaining, of the short distance between Todd's transit instrument and the boundary, it was found that the north end of the marked boundary line was about 2¼ miles to the west of the 141st meridian.

In the light of the present experience the longitude operations of 1868 can hardly be regarded as fundamental, and, moreover, the adopted longitudes of the Observatories of Melbourne and Sydney being at the time entirely dependent on transit observations of the moon, were not entitled to great confidence. Yet the means and methods employed in this later determination were so far superior to those of 1839 that a considerable error in the position of this boundary line, amounting to probably more than 2 miles, could be accepted as a tolerably well ascertained fact.

Then commenced the dispute between the adjoining States of South Australia and Victoria, the former claiming the strip of land upon which the latter State was encroaching. And the dispute grew even more vigorously after 1883, when the chain of telegraphically determined longitudes between Greenwich and Australia was completed, and further confirmed within sufficiently narrow limits the results of 1868. Eventually, in February, 1911, the case was taken before the High Court of Australia, which decided that the marked boundary having been accepted as such by the two States concerned, the fact that it did not exactly coincide with the 141st meridian of east longitude did not warrant the Court in ordering the re-adjustment claimed by South Australia.

In 1882 an arrangement was made between the British and Australian authorities that Captain L. Darwin, R.E., should go to Singapore for the purpose of carrying out, in co-operation with an Australian observer, who was to be stationed at Port Darwin, a determination of the difference of longitude between the two places, by the exchange of clock signals through the cable lines of the Eastern Extension Company, thus completing the longitude chain Greenwich-Australia by the telegraphic method.

The writer was sent to Port Darwin equipped with a transit instrument, by Troughton and Simms, of 3-in. aperture, clock, chronometers, and all necessary requisites.

Captain Darwin, similarly provided with the necessary instruments, established his temporary Observatory at Singapore.

Captain Helb, of the Netherland India Staff of Batavia, was instructed by his Government to proceed to Banjoewangie, where the two branches of

the cable between Port Darwin and Singapore join, and to take part in the longitude operations, so as to determine the intervals Banjoewangie-Singapore and Banjoewangie-Port Darwin, as well as the direct interval Singapore-Port Darwin.

Clock signals were exchanged by Port Darwin with Banjoewangie on 4 nights, with Singapore on 8 nights, with Adelaide on 6 nights, and with Melbourne on 4 nights, between the dates 28th January and 2nd March, 1883, inclusive.

By these operations the meridian of Port Darwin became the origin of Australian longitudes, and the following results were obtained and adopted at the time (26):—

	h. m. s.
Longitude of Port Darwin	8 43 22·49
Longitude of Adelaide Observatory	9 14 20·30
Longitude of Melbourne Observatory .	9 39 54·14
Longitude of Sydney Observatory .	10 4 49·54
Longitude of Hobart (Barrack Square) ..	9 49 19·80

A comparison of the telegraphic values of 1883 with those derived by absolute methods up to that time showed a more satisfactory agreement than could reasonably be expected.

Before dealing with the comparison, it will be necessary first to point out some results obtained by the method of occultations and culminations which have not yet been taken into account.

Russell observed a large number of transits of the moon and moon culminating stars in the years 1863, 1871, 1872, 1873, and 1874, from which he derived the value 10h. 4m. 50·81s. for the longitude of the Sydney Observatory, which he adopted from 1878. (29)

More transits of the moon and a number of occultations were observed at the Melbourne Observatory in the years 1874–75 for further verification of the adopted longitude, which confirmed the previously adopted value.

Also, Mr. John Tebbutt had very regularly observed many occultations of stars by the moon, and laid great stress upon the superior value of this method for improving the longitude of the Sydney Observatory and his own.

From 1863 to 1867 he had observed some 169 occultations, and by the end of the year 1878 had increased the number by 63 more, and having in the meantime determined the difference of longitude between his Observatory and that of Sydney, on several occasions, both by direct exchange of time signals telegraphically and by transportation of his chronometer, deduced the value of the longitude of Sydney Observatory based entirely on his own observations as follows:—

	h. m. s.	
Longitude of Windsor	10 3 21·81	
Difference Windsor-Sydney	0 1 28·83	
Longitude of Sydney Observatory ..	10 4 50·64	(30)

In 1884 Dr. Auwers deduced a fundamental value of the longitude of the Sydney Observatory based on the Australian observations both of transits of the moon and occultations (31). He found longitude of—

	h. m. s.
Sydney Observatory	10 4 49·60
Melbourne Observatory	9 39 54·17
Windsor Observatory	10 3 20·77

The comparison of results depending on the entire chain of telegraphic longitudes completed in 1883 with those derived by Dr. Auwers from lunar observations shows a discrepancy amounting to less than one-quarter of second of time, which was justly regarded as a nearly perfect agreement.

Subsequent longitude operations in Australia until the year 1903 were confined to those specified as follow :—

A re-determination in 1887 of the arcs Windsor-Melbourne and Windsor-Sydney by telegraph exchange of time signals which gave—

	m. s.	
Windsor-Sydney	1 29·39	
Windsor-Melbourne	23 25·87	
Melbourne-Sydney computed	24 55·26	(32)

A re-determination in 1887 of the interval Windsor-Sydney by transportation of chronometer on seven different dates and by triangulation, giving two new values for this, are as follow :—

Windsor-Sydney—	m. s.	
By transportation of chronometer ..	1 29·49	(18)
By triangulation	1 29·77	(32)

Determinations of the longitude of the Brisbane Observatory, Queensland, by exchange of time signals telegraphically between Sydney and Brisbane in the years 1884, 1891, and 1892.

Determination of the longitude of Broome, Fremantle, and Albany, Western Australia, in 1890 and 1891, by telegraphic exchange of clock signals between Commander Moore and Lieut. Parry at the above stations and the Adelaide Observatory.

Determination of the longitude of the Perth Observatory in 1899 and 1901 by exchange of clock signals telegraphically with Adelaide and Melbourne.

The resulting longitude of the Perth Observatory being based on the value 9h. 14m. 20·30s. for Adelaide and 9h. 39m. 54·14s. for Melbourne, giving—

Longitude of Perth Observatory—	h. m. s.	
Viâ Adelaide (1899)	7 43 21·74 E.	(33)
Viâ Melbourne (1899)	7 43 21·78 E.	(33)
Viâ Adelaide (1901)	7 43 21·97 E.	(34)

Determination of the longitude of a number of stations of the trigonometrical surveys of the States of New South Wales, Queensland, and Western Australia by telegraph exchange of time signals with the respective State Observatories.

The results of all these operations still depended on the value assigned to the longitude of the initial meridian of Port Darwin in 1883.

"The laying of the cable across the Pacific Ocean from Vancouver to Australia and New Zealand, some 8,273 nautical miles in length, was completed towards the end of the year 1902. It connects three intermediate stations on its course, namely, Fanning Island, Suva (Fiji), and Norfolk Island, and branches from Norfolk Island to Southport, in Queensland (Australia), and to Doubtless Bay (New Zealand)." (35)

"The importance of taking advantage of the first opportunity of determining the difference of longitude between Canada and Australia, along this route, was quickly recognised by the Canadian astronomers who, having previously established a chain of longitudes across the Atlantic between Greenwich and Canada, could now continue the chain to Australia to meet the end of the chain carried eastward from Greenwich to Port Darwin, thus closing a complete longitude circuit round the earth."

"The work having been authorized by the Canadian Government, Dr. Klotz, of the Ottawa Observatory, was commissioned to take charge of it, and in March, 1903, in conjunction with his assistant, Mr. F. W. O. Werry, B.A., Dr. Klotz commenced his great series of Trans-Pacific longitudes, which he concluded in January, 1904."

The results of Dr. Klotz are as follow.—

(39)

	h. m. s.
Adopted longitude of Vancouver	8 12 28·368 W.
Interval Vancouver-Fanning Island ..	2 25 5·406
Interval Fanning Island-Suva (Fiji) ..	1 28 43·837
Interval Suva-Norfolk Island	0 42 1·243
Interval Norfolk Island-Southport (Queensland)	0 58 1·364
	13 46 20·218 W.
Longitude of Southport (Queensland) ..	10 13 39·782 E.

A second fundamental meridian was thus established in 1903 on the eastern coast of Australia, the longitude of which was based entirely on the telegraphic method, and was quite independent of any other Australian longitude previously determined.

The arc Southport-Sydney having been measured by exchange of clock signals between Klotz and the officials of the Sydney Observatory, the entire circuit round the earth was thus closed, and a comparison of the two independent values for Sydney, based on the eastward and westward chains from Greenwich, gave the closing error.

At the time when the comparison was made (1903) a re-discussion of the Port Darwin longitude, based on all available records up to 1894, had been made (36), according to which the adopted value 8h. 43m. 22·49s. required to be reduced to 8h. 43m. 22·34s.

Also in the years 1894-96 the interval Greenwich-Madras was re-measured by Colonel Burrard and Colonel Lennox Conyngham, which involved a further reduction of 0·04s., and finally in 1903 a re-determination of the arc Greenwich-Potsdam and the re-adjustment of European longitudes by Dr. Albrecht and Prof. Wanach (37) (38) showed that the reduction had been carried too far by 0·01s.

The values adopted by Klotz in his comparison were—

Longitude of Sydney—

	h.	m.	s.
Viâ Eastern chain from Greenwich ..	10	4	49·355
Viâ Canada and Trans-Pacific longitudes	10	4	49·287
Closing error = 1·02″ = 84 feet = ..	0	0	·068 (39)

On the basis of all data available at the present time, the most probable longitude values of those Australian stations which form part of the Canadian circuit may be assumed to be—

	h.	m.	s.	
Longitude of Port Darwin	8	43	22·28	E.
Longitude of Melbourne Observatory ..	9	39	53·93	E.
Longitude of Sydney Observatory	10	4	49·33	E.
Southport (Queensland)	10	13	39·82	E.

Notwithstanding the remarkable agreement of independent results obtained by absolute and telegraphic methods in the determination of Australian longitudes, and the powerful check afforded by the closing error of the Trans-Pacific chain, it has been pointed out (35) that such evidence cannot as yet be accepted as the measure of the accuracy of the last longitude values just given above; and that a re-measurement of the intervals Southport-Sydney, Sydney-Melbourne, Melbourne-Port Darwin, Port Darwin-Singapore, Singapore-Madras is required before these values can be adopted with full confidence.

The Commonwealth Government is desirous of establishing a primary meridian to which all the Australian longitudes should be referred for the purpose of connecting the various surveys of the States to a common meridian datum. The present Federal Observatory of Mt. Stromlo is indicated as the appropriate point for the primary meridian of Australia. Indeed, this was one of the reasons for which Mt. Stromlo was selected as the site for the Observatory. This point could be very readily connected with one of the existing Observatories—Melbourne or Sydney—telegraphically or geodetically, but it has been suggested to the authorities (35) that adequate precision in the determination of the longitude of this meridian could only be obtained by completing a system of longitude measurements connecting Mt. Stromlo directly with the end of the Trans-Pacific chain at Southport on one side, and with the end of the Indian chain at Port Darwin on the other, and by re-measuring the intervals Port Darwin-Singapore and Singapore-Madras.

Great stress has been laid on the importance of carrying out this work soon and with due efficiency, in order to strengthen Australian longitudes.

The Mt. Stromlo Observatory.

In the beginning of the year 1910 the Government of the Commonwealth decided to erect a temporary Observatory at Mt. Stromlo, within the Federal Territory, at a distance of 7 miles to the westward of the centre of the Federal Capital "Canberra."

The immediate object was to test by astronomical and meteorological observations extending over one year, whether the atmospheric conditions of the site were sufficiently favorable to justify the authorities to establish on that site a permanent Astronomical Observatory of the highest order.

In due course an appropriate structure was constructed for the installation of a 9-in. refracting telescope equatorially mounted, and periodical observations were made for a few days in each month for nearly two years,

at the end of which (July, 1913) the observers reported that the site was favorable for the intended purpose.

The selected site is the summit of a group of hills rising, by gentle and graceful slopes, to an elevation of some 600 feet above the general surface of the surrounding country, and 2,660 above sea level. It commands an uninterrupted view practically down to the horizon on all sides, it affords ample room for a great institution, and its orientation, in respect of the city and of the prevailing winds, is favorable.

The temporary building consists of a central dome, 18 feet in diameter, resting on a circular wall of concrete, 8 feet above the floor, and four small square rooms symmetrically placed north, south, east, and west for the accommodation of the observers and caretaker.

The Oddie telescope, which has already been noted in connexion with the private Observatory of Mt. Pleasant, Ballarat, is the principal instrument. It has an object glass of 9-in. aperture giving excellent definition. The telescope is mounted on a massive cast-iron stand, resting on a pier of concrete built on a granite foundation. A metallic camera is attached in which is fitted one of Dallmeyer's portrait lens of 6-in. diameter and 38 inches focal length. The instrument is provided with a fine driving clock, excellent filar micrometer, electric illumination for dark or bright field, an Evershed prominence spectroscope made by Hilger, and every requisite for all classes of observations. The eye pieces range in power from 60 to 700.

This instrument was presented to the Commonwealth Government by the late Mr. James Oddie, of Ballarat, in July, 1910. I was commissioned to take delivery of it at Ballarat, and to erect it at Mt. Stromlo for the object stated above. As the instrument had never been taken out of its packing cases since the maker sent it out to Australia a quarter of a century before, it required a great deal of overhauling, and also several alterations and additions, which were done at the Melbourne Observatory.

The installation of the instrument at Mt. Stromlo was completed in September, 1911, after which observations were commenced and continued by myself and my chief assistant, Dr. J. Baldwin, during fifteen visits to the locality between 8th September, 1911, and 2nd June, 1913, each visit occupying about a week.

The observations were visual, photographic, and spectroscopic.

The visual observations were by naked eye and telescope.

The naked-eye observations were made for estimating the amount of scintillation at different altitudes, comparison of star regions, parts of the Milky Way, the Magellanic clouds, clusters, and nebulae. The telescopic observations included close double stars and detail of planetary surfaces. With the 6-in. doublet lens a series of photographs of rich star regions and nebulae was obtained.

The observation and delineation of solar prominences were also regularly carried out.

At the conclusion of our programme, I reported the result that in my opinion, taking into account all the circumstances, the site was decidedly suitable for an Astronomical Observatory of the highest order.

The question of proceeding with the establishment of a permanent Federal Observatory at this site is at present under consideration.

(2) GEODESY.

(a) Trigonometrical Surveys of High Precision.

Though many careful surveys have been effected in Australia, chiefly with a view to land settlement, trigonometrical surveys of high precision are, so far, confined to the three Eastern States. Of these only a brief description will now be given.

Queensland.

The trigonometrical survey in this State extends approximately from 26° 30′ to 29° 30′ south latitude, and from 151° 15′ to 153° 15′ east longitude. It comprises 74 triangles and a base line of about 7 miles in length situated at Jondaryan. Its terminals are Mount Irving and Mount Maria, which are respectively 216 and 162 feet above the general level of the intervening ground.

The measurement of this base was made in 1884 by means of two steel tapes 100 feet long, about half-an-inch broad, and 0·01 inch thick.

These were compared with a standard bar of steel octagonal in section 1½ inches in diameter and 10 feet long, which was kept floating when in use in a trough of mercury, with thermometers plunged in it for obtaining the temperature of the bar. This bar was compared in 1883 with the New South Wales Standard Bar O.I.4, which gave its standardized length at 62° F. as 9·9998581 feet, which value was adopted throughout the operations of the trigonometrical survey.

In the base measurements the two tapes were placed " in wooden troughs and shaded by a board, a tension of 20 lbs. was applied by means of a spring balance, and five thermometers, whose index errors had been determined by comparison with a standard thermometer, were used along each 100 feet of tape. The troughs were supported upon pegs driven in the ground and set on even grade by means of a levelling instrument. Marks were made in copper discs inserted in the pegs at each hundred feet, the distance between the tape ends and the marks being measured by micrometer microscopes.

Ten sections, the six central ones averaging nearly 1 mile and the other two at each end being nearly half-a-mile mile long.

The terminal points of these sections were marked by stones sunk into the ground and set in concrete. Each stone had a metal plug, upon which a small mark was made denoting the terminal point of the section."

Three measurements were made with each tape, giving six independent values.

The two sets of three values made with each tape gave two mean results, which showed a difference of 0·117 inches.

Ten-inch theodolites (Everest pattern), by Troughton and Simms, provided with micrometer microscopes reading to one second of arc, were generally employed on the survey, and a 12-in. altazimuth was used at a few stations.

The angular measurements were obtained from two to eight readings made on each of eleven positions of the circle. The closing errors were within 1″ for 29 triangles, from 1″ to 2″ for 29 other triangles, from 2″ to 3″ for 11 triangles, and upwards of 3″ for the remaining 5 triangles. The greatest closing error was 3·90″, and the average 0·95.″

" The astronomical datum is the position of the station at Jimbour as determined by Captain Morris, R.E., and Lieut. Darwin, R.E., in 1882," while they occupied this station for the observation of the transit of Venus.

The longitude was determined by direct exchange of time signals with the Sydney Observatory by telegraph. In deducing from this datum the latitudes and longitudes of the trigonometrical stations, the elements used by Colonel James in the Ordnance Survey of Great Britain, in 1858, were adopted.

The azimuth datum was determined by astronomical observations made with a 20-in. transit instrument at Bloodwood, this being the apex of one of the triangles standing on the base line.

Astronomical observations for latitude and longitude were also made at several stations.

A comparison of the astronomical with the geodetic values for the four stations of Bloodwood, Brisbane, Haystack, and Mount Domville gives the following differences respectively. (40)

Latitude (geodetic – astronomical) – ·02″; +1·17″; +5·37″; –1·17″.

Longitude (geodetic – astronomical) + 6·57″; –0·05″.

A minor triangulation of the City of Brisbane was carried out in 1890.

The principal triangulation was discontinued in 1891.

Victoria.

The preliminary work of clearing mountain tops for a trigonometrical survey of the State of Victoria was commenced in 1853 under Captain Andrew Clark, R.E., after his appointment as Surveyor-General of Victoria, as already mentioned; but the primary triangulation was not actually commenced till seven years after.

In 1860 a base line was laid down on the Werribee Plains about 4·942 miles in length, which was subsequently extended by triangulation to a further length of 5·651 miles, making a total distance between the terminal points 10·593 miles.

"Each end of the measured base was defined by a solid mass of masonry built 5 feet into the ground, capped by a heavy stone with gun-metal plug and platinum centre, on which the terminal dot was marked. A heavy protection stone was placed over the cap stone, and this was surmounted by a timber pyramid, with pinnacle accurately centred over the platinum point." (41)

The measurement of this base was made by three iron bars 10 feet long and 1 inch square, with the ends turned round for about 4 inches in length, one end of each bar being finished quite flat and polished, and the other end being a segment of a sphere of 5-ft. radius, also polished. They were encased in wooden troughs 6 inches square, with hinged tops cut in three sections for the convenient examination of the three thermometers resting on each bar, the steel ends only being freely exposed 2½ inches out of the case.

The lengths of these bars were compared with due care "with a 10-ft. ordnance standard lent by the New South Wales Government" (40) and verified later by a similar standard obtained by the Government of Victoria from the Ordnance Survey Department of England.

In the actual measurement the bars were supported on pine trestles fitted with brass sockets on their top frames to receive a brass tripod. These frames carried a brass "camel," provided with the requisite fittings for bringing the ends of the bars accurately into juxtaposition. The three bars were placed in series with distances of about ¼ inch between the spherical

end of one and the flat end of another, and the distance between the two was obtained by passing between them a graduated wedge of hard bell-metal 7 inches long and 2 inches broad, with faces inclined at angle of one-half a degree.

The difference of level between the terminal of the base being only 14 feet, and the intervening ground being fairly flat, the bars were adjusted by levelling into a horizontal position throughout the measurement.

A part of the southern portion of this base was re-measured to the extent of 2·11 miles, and the difference between the two results was found to be 0·308 inches, which was sufficiently small "to justify the assumption that by the original measurement the Werribee base was probably as accurate as any measured up to that time." (40)

The lengths of this base are as follow :—

(41)	Measured base	26091·82 feet
	Extension by triangulation to Green Hill terminal	29839·83 ,,
	Total length	55931·65 ,,

The instruments used for angular observations were an 18-in. altazimuth, by Troughton and Simms, and a 13-in. theodolite, by Ertel, both being provided with micrometer microscopes by which the circles were read to 1″; two 12-in. theodolites read by micrometer microscopes to 4″ and 10″ respectively; a 10-in. altazimuth and other theodolites of smaller size.

The triangulation was expanded in a decade throughout the extent of the Colony south of the 36th parallel of south latitude.

In this survey 209 stations of the first order, 267 of the second order, and a larger number of subsidiary points were connected and marked.

An average number of 170 observations were made at each of the primary stations to determine their positions. The triangulated area is about 70,000 square miles.

It was intended to measure a very suitable base of verification to the westward of Mount Gambier and Mount Schanck, in South Australia, these being the extreme western points connected with Victorian triangulation, but the work was not carried out.

A portion of the boundary line between the States of New South Wales and Victoria is a straight line running from a point near the source of the Murray River to Cape Howe on the east coast. The terminals of this line were agreed upon in 1870, and in order to determine their geographical co-ordinates with all possible accuracy, they were connected with the primary triangulation which was, for this purpose, extended to "The Pilot" and Mount Kosciusko, in New South Wales, these being the extreme eastern points of the survey.

The true azimuth of the line having been deduced by calculation from the co-ordinates of the terminal points, the line was ranged on the ground to the computed bearing and marked in 1872, starting from one marked terminal, and reaching the coast to within 17 inches of the other marked terminal.

The line was run by Messrs. A. C. Allen and A. Black, and the result is a fitting tribute to their skill, energy, and endurance in the accomplishment of an exceedingly difficult undertaking with such a remarkable success.

Colonel Clarke's elements of the figure of the earth were used in working out the results of the Victorian survey.

New South Wales.

The territory of this State extends from the Murray River to the 29th parallel of south latitude, and from the eastern coast westward to the 141st meridian of east longitude.

About one-fourth of its whole area has been covered with a trigonometrical survey of high precision, which was initiated in 1867, carried on for a few years, suspended for some time, resumed in 1891, continued since over an extent of 43 million acres, and still progressing.

The base line of this survey, 5½ miles in length, is situated at Lake George, and a verification base of about 7 miles was laid down and measured at Richmond.

The survey comprises 119 stations of the first order, 583 of the second order, and 1,380 of the third order, all of which have been very substantially and permanently marked and connected, and whose geodetic co-ordinates are accurately known.

Some 490 additional stations have been piled and prepared for observation, of which 15 are to be ranked as first order, 75 second order, and 400 third order stations.

The stations of the first order constitute the primary skeleton of the survey, being a net of fundamental triangles whose sides range usually from 35 to 40 miles in length.

Astronomical observations for azimuth, latitude and longitude were made at many of these primary stations.

The second order stations are distributed at distances varying from 15 to 20 miles, this being the average length of the sides of the secondary triangles. These stations were connected by actual observations made upon them with smaller instruments than those used at primary stations, but with sufficient precision to meet all the practical requirements of a triangulation for the purpose of accurate mapping. No astronomical observations were made at these stations.

The sides of triangles connecting stations of the third order are from 7 to 10 miles. The positions of these stations were fixed by intersections based on observations made from surrounding stations of higher order, and their accuracy is sufficient for connecting all chain surveys on a uniform system.

The original base on Lake George was laid down and its measurement commenced in 1868, under the superintendence of Mr. G. R. Smalley, but it was abandoned before completion owing to an abnormal rise of the water of the lake, which covered parts of the line to a depth of 2 feet.

A new site for the base was selected in 1870 by Mr. P. F. Adams, the Surveyor-General at the time, under whose direction the measurement of its length was made twice by Mr. A. C. Betts.

The adopted standard of length was that of "Standard Bar O.I.4." referred to at p. 175 of Colonel Clarke's work on the comparison of standards published in 1866." (41)

This bar is of cast iron, 10 feet in length, the length being defined by microscopical dots marked near its ends. It is encased, and fitted with

adequate support to prevent flexure, and provided with thermometers and micrometer microscopes for the observation of its marks. It was obtained many years before from the Board of Ordnance in England.

The actual measurement of the base was made with three 10-ft. bars of pine wood, encased and evenly supported, in wooden troughs 6 inches by 6 inches, and a little less than 10 feet in length, so as to allow a short portion of the ends of the bars to project outside. The ends were fitted with small brass plugs, upon each of which a terminal microscopic dot was marked, the distance between the terminal dots being the actual length of the bar. These lengths were standardized each morning and evening during the progress of the work by comparison with the Standard Bar O.I.4.

Each trough was supported on two "camels" provided with vertical, lateral, and longitudinal motion by means of which the three bars could be accurately placed in series along the line with the terminal dots of adjacent bars arranged in close pairs, always at the same distance, leaving a small constant amount of free space between the bars. This adjustment was made by means of a double microscope attached to the leading end of each trough. The microscope consisted of a single tube with two objectives at one end, rigidly mounted side by side, and two parallel webs, fixed on a diaphragm, at the upper end of the tube in the common focal plane of the objectives. By adequate means of adjustment the pair of dots could be brought in the fields of view and adjusted so as to bring each image into accurate bisection with each respective wire. The adjustment for parallelism of the optical axes and the distance between the webs having been previously ascertained, it was assumed that a constant distance between the adjacent bars was maintained throughout the measurement.

"The difference between the length of this base as found from the measurement and re-measurement was 0·542 inches in the total length of 5½ miles."

The verification base at Richmond was measured in 1879–80 by Mr. Conder twice.

The first measurement was made with the same three pine bars with which the Lake George base was measured, and in the second three 10-ft. rods of steel ⅜ of an inch in diameter were used. These rods were wrapped in blankets, and encased in wooden troughs with glass windows for inspection of the attached thermometers. The arrangement of terminal dots, the auxiliary apparatus for support, adjustment, and observations, and the methods employed in carrying out the work were in every respect similar for both sets of bars, and throughout the base operations at Lake George in 1870 and at Richmond in 1879–80. The length of both sets of bars was again standardized by daily comparison morning and evening with the same standard as adopted in 1870, namely, the Ordnance Bar O.I.4

The results of the two measurements were as follow:—

By pine bars	36989·33651 feet	
By steel rods	36989·39166 ..	
Difference	0·05515 .,	= 0·662 inches

"The combined error of measurement of the two bases and of the intervening triangulation produced an apparent discrepancy of only 1⅔ inches in the length of the Lake George base. The bases were assumed to be correct,

and an adjustment of the triangles was made in order to eliminate this small apparent difference." (40)

The instruments employed in astronomical observations and angular measurements were as follow :—

Two altazimuth instruments by Troughton and Simms, with object glasses of 3-in. aperture, provided with filar micrometer and delicate levels for latitude determinations by the Talcott method ; circles read by four micrometer microscopes to 1″.

All observations, astronomical and geodetical, were made with these instruments at the primary stations.

Theodolite by Troughton and Simms, object glass 2½-in. aperture and 26 inches focal length, horizontal circle 10 inches in diameter read by two micrometer microscopes to 1″, and two parts of a vertical circle 10 inches in diameter reading by vernier to 5″.

Observations at second order stations, and all vertical angles for the determination of relative heights, were made with this instrument.

Recently a 10-in. Repsold theodolite, of the same pattern as that used in the trigonometrical survey of South Africa, was procured, and is intended to be employed in the future in place of the heavier 18-in. altazimuth.

The observed directions from a primary station to another station of the first and second order depended on twenty pointings made in reversed positions of the instrument.

The number of pointings was reduced to ten for second order stations, and to five for stations of the third order.

The great accuracy of these observations is shown by the following statement of the closing error of triangles.

In 171 triangles in which all angles have been observed with the large altazimuth the closing error is 0·70″.

In 235 triangles, with two angles only observed with the larger, and one angle observed with the smaller instrument the average closing error is 1·15″.

In 245 triangles, in which only one angle was observed with the 18″ altazimuth, and the other two with the 10″ theodolite, the closing error is 1·29″.

In 173 triangles, with all the angles observed with the smaller instrument the closing error is 1·30″.

The probable value of the average closing error of the triangles, computed according to General Ferrero's formula, for the primary triangulation of New South Wales is 0·54″, which is less than the error similarly computed for the great trigonometrical surveys of Great Britain, India, and most of the other countries, and the closing error for triangles observed with the smaller instruments is, on the same criterion, reduced to 1·00″.

Astronomical observations for latitudes were made at 74 stations with the 18″ altazimuth by the Talcott method.

Azimuth was determined at 66 stations by meridian observations of circumpolar stars, made with the same instrument.

The longitude of 10 primary stations, and of 29 other important places in the State, were determined by the direct exchange of clock signals with the Sydney Observatory.

For the calculation of geodetic latitudes and longitudes, the co-ordinates of the Sydney Observatory adopted as the datum were :—Latitude 33° 51′ 41·1″; longitude 141° 12′ 23·1″.

The elements of the figure of the earth adopted in the calculations of the survey are those of a spheroid with—Major axis a = 20923134 feet; polar c = 20853429 feet.

Minor triangulations have been made around such important centres of the State as Sydney, Albury, and Newcastle, which were afterwards connected with the primary system.

Since the expansion of the geodetic survey of this State from the Lake George base in 1876, the principal observers in charge of the work were Messrs. W. J. Condor and J. Brooks. It was the former who set the high standard of accuracy which was worthily maintained by the latter.

Mr. T. F. Furber has been Director of the Survey for many years, and to him is due much of the credit of having planned means and methods by which this important undertaking has been brought to its present state of general efficiency and exemplary precision.

Mr. Furber, in his valuable paper (40) from which the information required for the above account was mainly drawn, mentions the names of P. F. Adams, late Surveyor-General, "to whom the very existence of the survey is in a large measure due," and the late H. C. Russell, who, during the whole progress of the survey, aided in many ways where his scientific attainments were of the greatest service.

In May, 1912, a Conference was held in Melbourne at which the Director of Commonwealth Lands and Surveys, the Surveyor-General, and the Government Astronomer of New Zealand, and the Surveyors-General of the Australian States met to discuss, among other things, the question of a Geodetic Survey of Australia.

The following resolutions bearing on this matter were passed by the Conference:—

(41) "That, in the opinion of this Conference, it is desirable that a Geodetic Survey of Australia should be undertaken.

"That, in order to give effect to the foregoing resolution, this Conference respectfully recommends that such survey be undertaken by the Commonwealth Government, and submits in support thereof the following reasons:—

"(a) That the time has arrived when the Commonwealth should take its place in the scientific investigations of the world, not the least important of which are the determination of the figure of the earth, its density, and other cognate matters.

"(b) That work of this character, involving the highest form of survey, should be effected under the supreme authority of Australia, as it is essential that it should be carried out with the greatest degree of accuracy on a uniform basis and a definite plan the individual parts being co-ordinated and eventually forming one homogeneous whole.

"(c) That the system which has hitherto prevailed by which the individual States carried out this work with instruments of varying character has resulted in divergent standards of accuracy, rendering the work to a great extent unsatisfactory, and, though much of it is of high grade, portions of it are impossible of reconciliation and co-ordination with a continental scheme.

"(*d*) That the desirableness of this work being undertaken by the Commonwealth Government is evidenced by the fact that the Geodetic Survey of the United States is carried out under the direct control of the Federal Government, and that the South African Geodetic Survey is also under one central control.

"(*e*) That such survey is absolutely necessary for the production of accurate maps, will be of high value in connexion with cadastral and geological surveys, and form a basis for topographical work for defence and other purposes. It will, moreover, provide a standard of accuracy for surveys of every description throughout the Commonwealth.

"(*f*) That it will afford an invaluable base to which settlement surveys already effected can be connected, providing data for re establishing boundaries, which, with increasing density of settlement, becomes a matter of great importance. Further, as regards the sparsely occupied areas of Australia, such a survey, if carried out in advance of settlement, will be of the greatest utility and assistance in effecting the settlement surveys which can at any future time be reproduced with a minimum error and at a relatively low cost, preventing litigation consequent upon other methods."

It is earnestly to be hoped that the Commonwealth Government will sanction the recommendations of this Conference, and that the proposed undertaking may be carried out, so as to enable Australia to furnish in due course a contribution which should prove itself to be one of the greatest value and importance for the advancement of modern geodesy.

(b) Pendulum Observations.

Determinations of the gravitational value of "*g*" have been made in Australia at various times by different observers, since the early years of the nineteenth century, generally, by differential methods based on the swings of pendulums of the "invariable" type, and, in one case, by the actual measurement of a "second's pendulum" of the reversible or Bessell's type.

The earliest gravimetric observations made in Australia seem to be those of the French Expedition under Freycinet, who swung three pendulums at Sydney in 1819, and the latest are those of Dr. Wright, of Canada, which he made at Melbourne in April of this year (1913) on his return from Scott's Antarctic Expedition.

During this period of 95 years, the value of "*g*" has been determined at all the capitals of Australasia one or more times independently, forming a series of 24 results, 9 of which are for Sydney, 7 for Melbourne, 1 for Brisbane, 1 for Perth, 1 for Hobart, 4 for New Zealand, and 1 for Campbell Island.

The whole of this work has been discussed by the International Geodetic Association, and a summary of it, with brief descriptions of the observations made, apparatus employed, and estimated probable error of each result, is published in the *Reports of the* 13*th*, 14*th*, 15*th, and* 16*th Conferenz der internationalen Erdmessung*, from which the appended table is taken.

The table shows, by the satisfactory agreement of the values obtained by several observers at different times, that the gravitational constant "*g*" has been well ascertained for the Australian stations.

DETERMINATIONS IN AUSTRALIA OF THE VALUE OF "g" REDUCED TO THE POTSDAM SYSTEM.

Station.	Latitude.	Longitude.	Height.	g	Observer.	Year.	g_0''	γ	$g_0''-\gamma_0''$
			m.						
Campbell Island	−52° 33′·7	169° 9′	(2?)	981·238	Boquet de la Grye ..	1874	981·239	981·293	− 54
Christchurch	−43° 31′·8	172° 38′·2	8	980 513	Bernacchi	1901, 1904	980·514	980·483	+ 31
Auckland	−36° 51′·9	174° 47′	80	979·938	Pritchett	1882	979·955	979·890	+ 65
,, ...	−36° 50′·9	174° 46′·2	3	979 962	von Elblein ..	1893	979·963	979·888	+ 75
Doubtless Bay	−34° 59′·3	173° 29′	7	979·839	Klotz	1903	..	979·729	..
Hobart	−42° 53′·6	147° 22′·0	58	980·441	Budik	1897	980·453	980 425	+ 28
Melbourne Mont Pellier Par. ..	−37° 49′·9	144° 59′	18	980·032	Neumayer	1863	980·036	979·974	+ 62*
,, Observatory	−37° 49′·9	144° 58′·5	26	979·991	von Elblein ..	1893	979·996	979·974	+ 22
,, ,, ...	−37° 49′·9	144° 59′	26	979 993	Baracchi	,,	979 998	979·974	+ 24
,, ,, ...	−37° 49′·9	144° 58′·5	26	979·997	Guberth	1894	980·002	979·974	+ 28
,, ,, ...	−37° 49′·9	144° 58′·5	23?	979·971	Bernacchi	1901	979·976	979·974	+ 2
,, ,, ...	−37° 49′·9	144° 58′ 5	27	979 985	Hecker	1904	979·990	979·974	+ 16
,, ,, ...	−37° 49′·9	144° 58′·5	27	979·985	Alessio	1905	979·990	979·974	+ 16
Sydney	−33° 51′ 6	151° 13′	33	979·716	Freycinet	1819	979·723	979·634	+ 92
,, Fort	−33° 51′·7	151° 13′	6	979·693	Duperrey	1824	979·694	979 634	+ 60
,, Observatory	−33° 51′·7	151° 12′·7	43	979·687	Pritchett, etc. ..	1882, 1894	979·695	979·634	+ 61
,, ,, ...	−33° 51′·7	151° 12′·4	43	979·678	von Elblein ..	1893	979 687	979·634	+ 53
,, ,, ...	−33° 51′ 7	151° 12′·4	43	979·698	Guberth	1894	979·707	979·634	+ 73
,, ,, ...	−33° 51′ 7	151° 12′·4	43	979·686	Budik	1896	979·695	979·634	+ 61
,, ,, ...	−33° 51′·7	151° 12′·4	43	979·674	,, ...	1897	979·683	979 634	+ 49
,, ,, ...	−33° 51′·7	151° 12′·4	43	979·681	Hecker	1904	979·690	979 634	+ 56
,, ,, ...	−33° 51′ 7	151° 12′·7	43	979·675	Alessio	1906	979·684	979·634	+ 50
Brisbane	−27° 28′·0	153° 1′·6	40	979·148	Budik	1896	979·1 6	979·129	+ 27
Perth	−31° 57′·1	115° 50′·5	58	979·374	Alessio	1905	..	..	..

* This value is without doubt erroneous, and should not be used.

The values in the table are from Bericht über die relativen Messungen der Schwerkraft mit Pendelapparaten in der Zeit von 1808 bis 1909 E. Borrass Verhandlungen 16ten allgemeinen Conferenz der internationalen Erdmessung.

In the table "g" is the observed value reduced to the Potsdam system.

Writing ϕ the latitude, H the height in metres, θ the density of the local earth formation, $g' - g$ the topographical reduction, then

$g_0 = g + 3086 \times 10^{-7} H$ the value reduced to sea-level.

$g_0'' = g_0 + \dfrac{3\ \theta}{4 \times 5{\cdot}52}(g - g_0) + g' - g$ the value corrected for the protuberant earth.

$\gamma_0 = 978{\cdot}030\ [1 + 0{\cdot}005302 \sin^2 \phi - 0{\cdot}000007 \sin^2 2\phi]$ the value computed from Helmert's formula.

$g_0'' - \gamma_0 =$ the gravitational anomaly.

I am indebted to the Government Astronomers and Surveyors-General of the Australian States for supplying me with accounts of the work of their respective departments; to Professor Ernest Scott and Mr. H. Wright for interesting historical notes on the astronomical work of early navigators; to Messrs. J. Tebbutt, C. J. Merfield, W. Gale, and H. Wright for information in regard to amateur astronomy; to Dr. J. M. Baldwin for arranging the results of pendulum observations; to Mr. J. A. Maroney for preparing the list of papers in Appendix B, and for giving valuable assistance in looking up authorities; and to some others who have helped me in various ways. To all of these I tender my sincere thanks.

The length of the original article far exceeded the limits of space prescribed by the Editor, and owing to my inability to deal with the difficulty, Dr. E. F. J. Love undertook the heavy and troublesome task of reducing to its present size, for which I am very greatly obliged to him.

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(3) APPENDIX A.

LIST OF REFERENCES.

Corresponding to the numbers (1) to (41) as quoted in the Text.

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(2) Australasian Association for the Advancement of Science. Vol. 1. Sydney Meeting, 1888: Section A. H. C. Russell—"Astronomical and Meteorological Workers in New South Wales, 1778 to 1860."

(3) Professor Ernest Scott. *Life of Flinders.*

(4) Catalogue of 7,385 stars prepared from observations made in the years 1822 to 1826 at the Observatory at Parramatta, New South Wales, founded by Lieut.-General Sir Thomas Macdougall Brisbane; the Computations made, and the Catalogue constructed by Mr. William Richardson. (London. 1835.)

(5) Memoirs of the Royal Astronomical Society. Vol. 3

(6) H. C. Russell. The Sydney Observatory: History and Progress. (Sydney. 1882.)

APPENDIX A.—LIST OF REFERENCES—*continued*.

(7) Memoirs of the Royal Astronomical Society. Vol. 8, p. 251.
(8) J. G. Galle. Verzeichniss der Elemente der bisher berechneten Cometenbahen. (Leipzig. 1894.)
(9) Astronomical Observations made at the Sydney Observatory in the year 1859 by W. Scott, M.A. (Sydney. 1860.)
(10) John Tebbutt. On the Progress and present State of Astronomical Science in New South Wales. (From the Industrial Progress of New South Wales, 1870, p. 617.)
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(16) Private Communication from H. B. Curlewis, Esq., Acting Government Astronomer of Western Australia.
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(18) John Tebbutt. Astronomical Memoirs (Sydney. 1908.)
(19) Monthly Notices of the Royal Astronomical Society. Vol. 25, p 197.
(20) Astronomische Nachrichten. Vol. 64, p. 109.
(21) Observations of the Transit of Venus, 9th December, 1874, made at Stations in New South Wales. (H. C. Russell.) Sydney. 1892.)
(22) Monthly Notices of the Royal Astronomical Society. Vol. 44, p. 310.
(23) Monthly Notices of the Royal Astronomical Society. Vol. 20, p. 77.
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(25) Astronomical and Meteorological Observations made at the Sydney Observatory in the year 1860 by W. Scott, M.A. (Sydney. 1861.)
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(27) Victoria. Third Report of the Board of Visitors to the Observatory, with the Annual Report of the Government Astronomer. (Melbourne. 1863.)
(28) South Australia. Observatory and Telegraphs. Annual Report by Charles Todd, Esq. 1867. (Adelaide. 1868.)
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(30) Journal and Proceedings of the Royal Society of New SouthWales. Vol. 14, p. 20.
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(33) W. E. Cooke. Report on the Latitude and Longitude of the Perth Observatory. Western Australia. (Official Report to the Under-Secretary. 21st September, 1899.)
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(36) Australasian Association for the Advancement of Science. Vol. 6. Brisbane Meeting, 1895. Section A. P. Baracchi—On the most Probable Value and Error of Australian Longitudes, including that of the Boundary Lines of South Australia with Victoria and New South Wales.
(37) Veröffentlichun des Königl. Preuszischen Geodätischen Institutes. Neue Folge, No. 15.
(38) Astronomische Nachrichten. No. 3993–94. Albrecht.
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(41) Commonwealth of Australia. Department of Home Affairs. Conference of the Director of Commonwealth Lands and Surveys, the Surveyor-General and the Government Astronomer of New Zealand, and the Surveyors-General of the States of the Commonwealth of Australia. Melbourne, 20th to 25th May, 1912. (Melbourne. 1912.)

(4) APPENDIX B.

SOME ASTRONOMICAL PAPERS PUBLISHED BY AUSTRALIANS.

NOTATION.

Astr. Reg.	for "Astronomical Register."
J.R.S. N.S.W. ..	for "Journal of the Royal Society of New South Wales."
M.N. R.A.S.	for "Monthly Notices of the Royal Astronomical Society."
J.B.A.A.	for "Journal of the British Astronomical Association."
Trans. R.S. S.A. ..	for "Transactions of the Royal Society of South Australia."
Ap. J.	for "Astrophysical Journal."
P. & Prcs. R.S. Tas. ..	for "Papers and Proceedings of the Royal Society of Tasmania."

NEW SOUTH WALES.

W. J. MacDonnell, F.R.A.S. (1871).

Notes from the Southern Hemisphere ..	Astr. Reg. ..	Vol. 9, p. 145
B.A.C. 5554	.. ..	Vol. 10, p. 18
Transit of Mercury, 1878	.. .. .	Vol. 16, p. 207
Notes on the Observatories in the United States	J.R.S. N.S.W. ..	Vol. 12, p. 229
On Star-discs and the Separating Power of Telescopes	.. .. ..	Vol. 12, p. 241
Observations of the Transit of Mercury, 10th May, 1891	M.N. R.A.S. .	Vol. 51, p. 560
Note on a Dark Transit of Jupiter's IVth Satellite	J.B.A.A... ..	Vol. 7, p. 401
The Fifth Star in the Trapezium	.. . .	Vol. 13, p. 28
The Recent Sun-spots (October, 1903) ..	.. . ..	Vol. 14, p. 121
Address on retiring from the Presidentship of the N.S.W. Branch, B.A.A.	., .	Vol. 15, p. 80
Occultation of Saturn, 27th October, 1906 ..	.. .. ..	Vol. 17, p. 136
On the use of Screens for the Reduction of Glare and improvement of Definition of Telescopes	.. .. .	Vol. 18, p. 44
Jupiter's third Satellite	.. .. .	Vol. 19, p. 356
Comet 1908 *c*.	.. .. .	Vol. 19, p. 352
Occultation of Venus by the Moon, 19th November, 1909	.. .. ..	Vol. 20, p. 152
Halley's Comet	.. . ..	Vol 20, p. 200
Galileo Galilei	.. .. .	Vol 20, pp. 258, 485
Marius *v*. Galileo	,, .. .	Vol. 21, p. 32

G. D. Hirst, F.R.A.S (1876.)

Some Notes on Jupiter during his opposition..	J.R.S. N.S.W. ..	Vol. 10, p. 83
Remarks accompanying Drawings of Mars (1877)	M.N. R.A.S. .	Vol. 38, p. 58
Notes on Jupiter during his opposition ..	J.R.S. N.S.W. ..	Vol. 12, p. 238
Remarks on the Colours of Jupiter's Belts and some Changes observed thereon during the opposition of 1880	,, .. .	Vol. 14, p. 77
Notes on Mr. Cobham's Paper on "Astronomical Drawing"	J.B.A.A. ..	Vol. 15, p. 104
Presidential Address, N.S.W. Branch, B.A.A., 1905	J.B.A.A. .. .	Vol. 16, p. 95
Note on α Centauri	.. .	Vol. 17, pp. 34, 35
Some Remarks on "Wiring" Astronomical Instruments	.. . ..	Vol. 18, p. 40
Measures of some Southern Double Stars ..	,, . ..	Vol. 18, p. 174
Note on *p* Eridani	,, ...	Vol. 19, p. 141
Southern Double Star Measures	M.N. R.A.S. ..	Vol. 70, pp. 474, 644

APPENDIX B.—SOME ASTRONOMICAL PAPERS—*continued.*

NEW SOUTH WALES—*continued.*

F. K. McDonnell. (1895.)

An Appliance for the Direct Comparison of Star Colours	J.B.A.A..	Vol. 5, p. 517
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CHAPTER IX.

THE PASTORAL AND AGRICULTURAL DEVELOPMENT OF AUSTRALIA.

By G. A. Sinclair, Agricultural Editor of the "Australasian," Melbourne.

SYNOPSIS.

In the above title the word pastoral naturally comes before agricultural, inasmuch as the first serious efforts towards developing Australia's natural resources were in the direction of grazing, and, moreover, the island continent is world-famous for its wool, while in butter and frozen meat, important industries have been established and a rapidly increasing export trade has been built up with the older continents.

1. Sheep-Farming.

(a) Merinos.

The "romance of the wool trade," as far as the establishment of the merino in Australia goes, has often been told, and requires little recapitulation here. It is curious to notice, however, that the first merinos which were landed in Sydney came from South Africa; while, for some seasons past, buyers have come from that country to Australia to purchase stock of the best strains, which are almost as well-known in South Africa to-day as they are in Australia. It was, no doubt, a fortunate circumstance that the sale of these sheep was coincident with the sailing of a vessel for Australia, but it must be remembered that for some time previous, the early settlers of New South Wales had had the improvement of their flocks in mind, and to the care and skill exercised by them and their successors, aided by excellent pastures, the pre-eminent position at the present time of the Australian merino and its wool is undoubtedly due.

There is a great difference between the merino of to-day and the animal which landed here in 1797. At Camden Park, in New South Wales, the descendants of the original flock have been kept pure and free from admixture, but they are in every way inferior to the best modern flocks.

In breeding merinos up to their present state of excellence, a skill and science have been shown which are unrivalled in the history of stock breeding. The expert classer is a scientist to whom the theory of Mendel is as familiar as the drafting yard where his skill is displayed. To see him at work, selecting the sire to build up or maintain the qualities of the flock, whether in constitution or in wool, is a revelation, not only in sound judgment, but in quick decision. To show the skill of breeders, may be instanced the

craze of a few years back for "wrinkly" sheep, when Tasmanian flocks in compliance with the demand, developed the deep folds. It has been said that "Vermont" blood was used to secure the result, but though in a few isolated instances this may have occurred through "get-rich-quick" desires, it is certain that, in the best flocks, no such importation was used. When the tide set the other way, the wrinkles were ironed out as quickly as they had been introduced, and at the last Campbell Town Show (Tasmania)—one of the foremost in "merino" importance in Australia—the characteristics were plain body, splendidly clothed, with wool of long staple and good quality.

In a season like the present (1913) it is impossible to write in any way but enthusiastically concerning merinos. Possibly never in the annals of the breed have the sheep in the various States looked better than at present, and the prospects for good wool prices are excellent. This is emphasised by the sale of two rams at prices only once before exceeded, namely, in 1883, when two brothers, bidding against each other without knowing it, sent up the price of a ram from 300 guineas to 3,150 guineas. This year two rams have fetched 1,700 and 1,600 guineas respectively, while prices of 500 guineas and over are not uncommon.

Of those who, by their forethought, energy, and perseverance, laid the foundations of this great industry the list is long and honorable. Each State had its pioneers who in those early years braved the dangers of marauding natives, disease, and drought, some to win success, and to found those flocks the names of which are to-day household words in the sheep-breeding industry, others, less fortunate, to fall by the way, broken by bad seasons and pests.

To show the importance of the industry built up by these men and their successors it is only necessary to mention that the total export of wool for 1807 was 245 lbs., while for 1911–12 it was 1,967,818 bales; and for 1912–13, 1,696,146 bales.

The wool sales, too, have undergone a considerable change of venue of late years. Formerly all the clips were sold in London, and the prices realized were quoted in detail in *The Australasian*, the columns of which were eagerly scanned each week for the results of the home and neighbouring consignments. To-day the buyers from England, France, Germany, United States, and in fact all manufacturing countries, attend the sales in Sydney, Melbourne, and Geelong, and bid against one another for the choicest clips, whose brands they know as well as do the station-owners. Where local agents act for European firms, they find it necessary to visit their principals every few years to keep in touch with the manufacturing changes. The unsatisfactory methods and the discomforts of the old London sales have disappeared. Now, in a well-lighted room, hundreds of buyers for firms of world-wide fame compete by fractional bids for the wool in thousands of bales, samples of which have been opened and subjected to minute inspection previously.

The honour of gaining top price for wool in any season is highly prized among breeders, and does not always fall to well-known flocks. Thus, last season, for Victorian-sold clips, a comparatively small farmer of the Wimmera country in the north-west gained the coveted position, obtaining 19¼d. per lb.

for merino fleece, a figure which will give some idea of prices realized at the present day. This is not peculiar to Victoria, for, in New South Wales, a farmer with an area of under 500 acres secured the top price of 17½d. per lb.

This shows that small farmers may engage in the calling with profit; and when, in course of time, the large holdings of Victoria and the Riverina are subdivided, the merino of high quality need not necessarily disappear, provided that the small breeders have procured their sheep, in the first instance, from the fixed strains of well-known flocks. To show how the larger breeders fare, it may be mentioned that out of a clip of 306 bales including locks, etc., 114 bales realized 16½d. per lb. or over. For super. lambs' wool another clip obtained 23½d. per lb. Again, for his 1910 clip, a South Australian breeder showed the following figures:—18,125 grown sheep cut an average of 13 lbs. 7¾ ozs. of wool each; 6,701 lambs cut an average of 4 lbs. 3¾ ozs. each; 24,826 sheep and lambs cut 781 bales of wool, which averaged £12 2s. 5d. per bale; average price per lb. for all sheep and lambs' wool, 8½d.; average money yield per head for grown sheep, 9s. 6d. gross.

The Commonwealth Statistician shows that for the year ending 30th June, 1912, the percentage of wool exported from the various States was—New South Wales, 44·4 per cent.; Victoria, 27·8 per cent.; Queensland, 14·3 per cent.; South Australia, 8·8 per cent.; Western Australia, 3·8 per cent.; Tasmania, 0·9 per cent. It is possible that the advance of agriculture and of the frozen meat trade may cause a decline in wool production in future; but, on the other hand, it is more than likely that the centre and north of the Commonwealth will afford a haven for the large flocks, while the southern States will breed the pure sheep necessary to maintain the quality of the wool.

(b) British Breeds.

While merinos hold the pride of place, it must not be supposed that our early efforts were confined to that breed. Merinos were found to be unsuited to the coastal districts, and Lincolns and Leicesters were early introductions, to be followed later by Shropshires, Southdowns, Hampshires, Border Leicesters, Romney Marsh, and others. But, while merino men soon dropped importations of Rambouillet, Negretti, and other strains, finding they could breed better, the mother country has been drawn on for "British" breeds until within recent years. Even now occasional importations are made of Romney Marsh sheep, the most recently fashionable; but, sooner or later, after starting with the best British blood as a foundation in each breed, it is found that the conditions in Australia are so congenial that further importations are unnecessary.

Before leaving the subject of wool, it may be pointed out that the improvements in manufacturing, by which so much more use can be made of the coarser kinds, have given a greater impetus to crossing the merino with Lincoln, Leicester, and other breeds. The crossbreds, too, fit in with farming operations better, as they can be used with greater advantage for keeping the fallow clean; and, last of all, but not least, the meat export trade has made the rearing of fat lambs so profitable that the high quality merino flocks

of the Riverina and the western district of Victoria are being slowly pushed out north and west, until there is some reason to fear that these districts, probably unequalled for the quality of their wool, will be lost to the industry.

The term crossbred is applied on the mainland at any rate to the progeny produced by crossing merino ewes with Lincoln rams; and it is interesting to compare the prices realized for wool of this character in an ordinary year. These are some of the prices for the season of 1911:—Comeback fleece, Green Hills, 15d. per lb.; comeback lambs, Mooline, 15d.; crossbred fleece, North Station, 14d.; Kinonynie, 14d.; Green Hills, 14½d. In the previous season Green Hills for 340 bales comeback wool averaged nearly 13¾d., 37 bales reaching 15d.

While considerable skill has been shown in breeding for the frozen meat trade, much still remains to be done, and it would no doubt benefit the industry if lambs were sold according to quality of carcass and not solely by weight. At the present time, breeding for fat lambs is not conducted on very definite lines. The difficulty is that the Australian cannot help regarding the sheep as primarily a wool producer. To him, the very *raison d'être* of the sheep is its wool, and he thinks it advisable, in case of the lambs not selling as fats, to have them well-woolled as a compensation. Even after introducing Shropshires, breeders immediately set to work to improve the wool, and succeeded to a remarkable extent, but not, it is feared, without detriment to the frame.

The consensus of opinion now is that for those districts where early lambs are most easily raised big-framed crossbred or comeback ewes should be used and put with rams of Shropshire, Southdown, or similar breeds. Opinions differ as to whether the Lincoln cross or Leicester or Border Leicester, or even Romney Marsh cross, is best to use. Some pin their faith to these breeds crossed with the merino, without using any Down sheep; but for early lambs, according to the figures of several years, the crossbred-Shropshire lamb invariably tops the market. In support of this statement may be quoted the prices for three years of a northern district crop of lambs. These were 11s. 9d., 12s. 3d., and 13s. 6d. per head at the nearest railway station, and were bought for freezing. They were not picked sheep, but represented the whole season's drop from a little under 1,000 ewes. Another breeder, in a later district, obtained 19s. per head for four months' old lambs. In both instances crossbred ewes were put to Shropshire rams. As the ewes in the first case mentioned cost very little more than the price realized by the lambs, it can be seen what profit there is in the industry, particularly when fodder crops are grown as a safeguard against dry autumns. The market is a good one and ever expanding. The opening of the North American and European ports promises a further demand for this product, and, by studying the quality of the meat required, there is every prospect of Australia capturing the bulk of the trade.

One of the most recent moves in connexion with this industry is the establishment of inland freezing works in the centre of that important lamb-raising district, the Wimmera. The object is to slaughter on the spot, thus reducing freight, and at the same time avoiding the wasting of flesh which occurs during the rail journey to the seaboard (estimated at about 5 lbs. per head for lambs). So far this enterprise, which is co-operative, has been very

successful; but it remains yet to be seen whether labour troubles, which have wrecked several New South Wales inland works, will hamper this. A similar movement is on foot in the Goulburn Valley; and, no doubt, others will follow if these prove successful.

A great incentive will be given to the fat-lamb export trade by the opening up of additional routes to the seaboard in the eastern States. Portland, for instance, in south-west Victoria, when connected by rail through the Wimmera to New South Wales, will be the port of shipment for products from a vast territory. Again, the linking up, now being carried out, of the Riverina railways with those of the Goulburn Valley, will tap additional large areas. In New South Wales and Queensland, new territories are being brought rapidly into communication with the ports; and the trade may safely be said to be as yet in its infancy. The growth of this trade up to the present may be learned from the following export statistics:—Season 1904–5, mutton, 550,112 carcasses; lamb, 702.898; season 1911–12, mutton, 2,076,208 carcasses; lamb, 1,477,131. This latter season was not marked by a particularly large exportation and was exceeded in that respect by the seasons for 1909–10, and 1910–11, 2,296,980 carcasses of mutton and 1,685,985 carcasses of lamb having been exported to various countries in the latter year.

The adaptability of the crossbred to Australian conditions has led to the founding of strains, which may now be said to be fixed in type, and combine good quality fleeces with good mutton frames. Of these Australian breeds are the Carrsdales and Ideals, which cut a valuable fleece, and are admirable for procuring freezer lambs when crossed with the Down breeds. Of late years a New Zealand breed, the Corriedale, has gained a footing on the mainland, and promises to become popular.

2. Cattle.

The rearing of beef cattle in Australia has not kept pace with the sheep industry, and may be said to be now confined, on extensive lines at any rate, to Queensland, Central Australia, Western Australia, and the Northern Territory. The breeding of Shorthorns and Herefords, for which the western district of Victoria was once famed, has now been, to a large extent, abandoned for dairying. There are, however, in the southern States a number of pure herds of these breeds, and of a high-class character. The bulls and cows imported in the early days as a nucleus, were of the best Bates and Booth blood obtainable; and the sums paid for them astonished English breeders of the day. Thus, £2,500 was paid for Oxford Cherry Duke (32016), while his calves of between eight and twelve months averaged £458 17s. A big price paid in Australia was £1,732 10s. for Earl of Geneva, in February, 1875, while in 1878 2,450 guineas was given for 24th Duke of Derrimut. As much as £27,000 has been paid for a herd of 37 head, but the prices paid at the present time are much more modest. Thus at the last Sydney Royal Show sale the highest figures obtained were under 300 guineas.

At the same time a considerable trade is springing up in frozen beef, which, in consideration of the fact that the world's consumption has increased in far greater measure than the supply, will probably become greater, and lead to better utilization of the Northern Territory lands. In the season 1904–5,

101,662 quarters of beef left Australia for other lands, principally for South Africa, while in 1911–12, the quantity exported was 618,313 quarters. Comparing it with that obtained by other exporting countries, the price realized is usually a little below that of New Zealand beef, which is fattened on artificial grasses and has but a short way to travel to the port, and a little above that of Argentine beef. Queensland provides the greater part of this trade. The southern States will probably, in the future, raise pure stock to keep up the character of the northern herds.

3. Dairying.

Mention has been made of the detrimental influence dairying has had on the raising of fat cattle in the southern States; but nevertheless the industry has brought great wealth and prosperity to the Commonwealth. In 1911, the total production of butter in the Commonwealth was 211,577,745 lbs.; of cheese, 15,886,712 lbs.; of milk, 5,947,269,640 lbs.; of condensed milk, 22,983,707 lbs.; and of bacon and ham 53,264,652 lbs. The value of exported butter alone was £4,637,362. As an idea of the relative values of the exported products it is interesting to note that, in the same year, wool totalled £26,071,193; frozen mutton and lamb, £1,633,622; frozen beef, £1,102,132.

Victoria led the way in developing the dairying industry; and of the early buttermakers and teachers, the name of David Wilson stands pre-eminent. In the eighties and early nineties, the separator was winning its way into prominence, co-operative butter factories were springing up all over the land, and the quality of the product was improving in a wonderful degree. When the financial depression occurred after the collapse of the land-boom, butter-making was on a firm foundation and the quick recovery from that depression was, in a great measure, due to this industry.

When it was seen what great profit there was in dairying, the large land-owners in the western district of Victoria cut up their properties into small holdings, and let these to small farmers for dairying on shares. The main features of this system are that the landlord provides land, buildings, stock, machinery, etc.; the tenant furnishes labour, and the landlord takes two-thirds of the butter-fat returns the receipts from pigs being equally divided between the parties. So successful were most of these small farmers that they now own their own farms, having paid from £40 to £80 or even £100 per acre. The soil is wonderfully rich, and the climate suitable, rye grass and clover growing luxuriantly, while lucerne and maize provide ample fodder for the autumn and winter without any irrigation. Good roads, too, are easily made and kept up.

Gippsland is another dairying province with all the favorable natural conditions, but bad roads greatly hamper her progress. Steps are however now being taken to improve them.

For a time the dairying industry made great headway in the northern districts where land was cheaper, and means of communication good; but, after the great drought of 1902, and with the improved prices for grain, wool, and sheep, many reverted to the old farming methods. At the present time, dairying is flourishing in Northern Victoria only on irrigated lands, or where the rainfall is ample, as in the King River Valley.

In New South Wales the dairying districts are the South Coast and the northern rivers; and great progress has been made, the output of that State being at present not far behind that of Victoria.

In Queensland the industry is increasing rapidly, the rich Darling Downs being now a huge dairying province. Queensland's output is about one-third that of Victoria. One cannot fail to realize how much the rural producer owes to scientists whose researches in refrigeration have enabled perishable products to be manufactured in hot climates and conveyed on long voyages to the marts of the world.

At the present time the export trade in butter is at a critical stage. The cheapness and excellence of home separators, and the saving of haulage by their use, led to their almost universal adoption about ten years ago. A number of factories stood out against their use, recognising the effect which the irregular ripening of the cream would have on the quality of the butter, but, one by one, they were forced to fall in line. The consequence has been the disappearance of most of that superfine article for which the best factories were famous. There is no doubt about the deterioration. It is proved by comparing the prices at present obtained for Australian butter and that of our two great competitors, Denmark and New Zealand, with the prices realized a few years ago.

There is no need for this deterioration. The only things necessary are cleanly conditions and the delivery of cream to the factory at frequent intervals. The high prices received in Europe, in the season 1911–12, for butter of any kind, did immense harm to the industry in Australia, as it engendered a carelessness, which the sharp lesson of falling prices is now correcting. The authorities in the various States are now endeavouring to improve the quality of the output by legislation, the direction taken being that of compulsory grading of cream, with the licensing of factory managers. This, it is believed, will prevent cream rejected at one factory being accepted at another.

The Commonwealth had previously endeavoured to control the industry by compulsory grading of butter at the ports; but, through a flaw in the Act, this supervision was summarily stopped by action at law, though quite 80 per cent. of the butter sent away from Victoria is still voluntarily graded. The competition of margarine is shutting second-class butter out of the English market, and strenuous efforts are now necessary to prevent any but first-class butter leaving our shores.

In another direction, too, there is great room for improvement, and that is in the return per cow per annum. Taking Victoria as the leading dairying State, the average annual return per cow is under £7; while, if labour, rental, value of land, etc., be taken into consideration, the cost of keeping a cow amounts to £6 10s. per annum. As many herds are returning £14, £15, and even £20 and upwards per cow per annum, there is evidently great room for improvement in the average herd. Efforts are being made to improve matters in New South Wales by the encouragement of milk-testing and weighing societies, and in Victoria by the issue of certificates to cows giving standard returns in pure herds, which have submitted to official tests. Indifferent milkers will thus be culled out, and only milking strains on both sides used for breeding.

As to the cattle employed in dairying, all the recognised breeds are well represented in Australia. The Jersey may be said to be the favorite with buttermakers at present, though the old-time Ayrshire, bred from the best strains imported years ago, is slowly working its way back to favour, as it is found that by culling judiciously, not only quantity but a high butter-fat test is obtained. Importations of high-priced Jerseys of milking strains are still constantly made. Guernseys, too, have admirers, while a number of the Shorthorn breeders have developed milking strains in their herds, which compare favorably with any other breeds. In New South Wales is a breed—the Illawarra—which is the favorite in some wide districts, and is practically a milking type in which Shorthorn predominates. In Tasmania some years ago the Alderney was well represented. Throughout the Commonwealth the present tendency is, whatever breed is used, to look for milking strains on both sides; and the increase of butter-fat per head, combined with care in manufacture, will put the Australian dairyman in the position to sell a better product more cheaply, and, aided by good pastures and fine climate, to still make a handsome profit.

The best dairymen make ample provision for feeding their cows during autumn and winter, either with green fodder crops, hay, or ensilage, or with all three; oats, wheat, or lucerne is used for the hay, and maize or mixed crops for ensilage. The use of the silo is spreading slowly all through the country. Not only does the progressive dairyman now regard it as a necessary equipment, but even sheep breeders are storing away surplus feed for future needs.

A great feature in connexion with dairying is the development it has caused of co-operative principles amongst farmers generally. Starting with co-operative butter factories, the movement has spread to the handling of farm products of all kinds, and the purchase of machinery, bags, seed, etc. The latest phase in this development is the establishment of bacon-curing factories in New South Wales and Victoria. Pig breeding has always been considered a necessary and usually a profitable adjunct to dairying; but a couple of seasons ago pigs were unsaleable. To remedy this, co-operative works were started for the curing and exportation of surplus pork, so that no trouble may be anticipated in the future.

It should be noticed that, besides butter, cheese and condensed milk are manufactured in considerable quantities in the Commonwealth, while powdered milk is also on the market.

The one great drawback to the dairying industry is the difficulty in procuring labour. This has led to the employment of milking machines, which, where reasonable care and cleanliness are employed, are proving entirely satisfactory. Many of those in use are of Australian manufacture.

Dairying on shares seems one of the most satisfactory methods of profitably employing suitable land, especially to families with small capital arriving from overseas. In one instance, two young Englishmen (Londoners) have each been making £180 a year with a Gippsland dairy-farmer. In another case, a Scotch farmer and his family have a steady income of £400 per annum Their small capital remains untouched and is added to from

year to year, while in the meantime they are gaining experience of Australian conditions. It has been stated that one large landowner in a very fertile district guarantees a man and family £500 per annum.

4. Agriculture.

(a) Grain Crops.

Possibly to the outside superficial observer Australia appears a land of sheep stations alternating with wheat-fields. It will be found, however, on closer observation, that where climatic conditions permit it, mixed farming on lines closely approximating those found profitable in the older countries, has been carried on for many years. The districts where this form of agriculture is so successful were settled by the yeomen from Great Britain, thoroughly trained farmers, whose descendants to-day are among the most skilful tillers of the soil.

In common with other lands, Australia has made great strides in agriculture, particularly in the wheat-growing areas, during the last decade, owing to the better methods of cultivation employed and to the increased use of artificial manures. The present methods of cultivation, the chief feature of which is the almost universal bare fallow before a crop, are the result of experience; but for their knowledge of the value of manures, farmers are indebted to the instruction given and experiments carried out by officers in the Agricultural Departments of the various States. The early wheat farmers, most of whom were old-time gold diggers who selected land when the alluvial fields became worked out, had a hard fight before their success was assured.

Land could be selected for £1 per acre, the payments being spread over long terms of years; but the cost of clearing, fencing, buildings, and implements soon exhausted the selectors' capital and earnings, and advances could not be secured until a Crown lease was issued, which was not done for several years after selection. Their wheat had to be carted long distances—often 50 miles or more—to the nearest railway station, and labour of any kind was dear. It is not to be wondered at then, that, as a rule, they were content to crop the same piece of ground for several years and only turn their attention to another block when the first showed signs of exhaustion. With better facilities for marketing produce, and with more money for purchasing implements, improved methods have been followed, and to-day the wheat-growing areas promise to retain their fertility for many years to come.

The general cropping practice is as follows: in the springtime—July and August—the land for the next year's crop is ploughed to a depth which depends on the character of the soil, about 7 inches being the rule in the Riverina, the Goulburn Valley, and South Australia, and from 3 to 4 inches in the Wimmera and other heavy clay loams. It is then harrowed and worked down fine with a cultivator or scarifier, and after every shower the harrows are put over the fallow to form a mulch, and arrest loss of moisture through evaporation. This, briefly, is the Australian "dry farming" system, evolved by her practical farmers. Sheep also are used to keep the fallow clean, their droppings helping to supply organic matter, and since the rise of the frozen meat trade, cropping and sheep-raising go hand-in-hand. On some

light soils, which, if worked fine, set like cement with heavy rain, the land is left in the rough after ploughing, and only sheep are used to keep it clean. After the first autumn rains, which are anxiously looked for by the beginning of April, the weeds which have sprung up are turned under, the land is harrowed and the seed is sown with a drill, from 50 to 60 lbs. of seed and 50 to 80 lbs. of superphosphates being used per acre. After drilling, the seed is covered by harrowing, and occasionally the land is rolled to consolidate the soil. Many farmers make a practice of feeding down their crops to make the plants stool out better, while at the same time providing feed for the ewes and lambs. Rains may usually be expected in June, July, and August, but the critical period for the crops is in October and early November. Rain falling or withheld about that time makes or mars the yield. Hay cutting, which means cutting wheat or oats with reaper and binder, takes place in November, and the earliest varieties of wheat are ready for harvesting in December.

Not many grain crops are cut and threshed; but it is sound farming to use this method with oats, as less grain is lost and the straw is invaluable on the farm. In harvesting her grain, Australia has her own peculiar machine to use—the stripper—which, with its improvement the harvester—has enabled her growers to contend with scarcity of labour and comparatively low yields. It is common knowledge that the Australian stripper originated in South Australia in 1845, the invention of J. Ridley, but it is not so well known what struggles and difficulties the early mechanics had before they brought the harvester to its present state of perfection. In 1879 the South Australian Government gave a great incentive to inventors by offering a prize of £4,000 for a satisfactory machine. This attracted, besides local men, competitors from Victoria, and even from far California. No machine was awarded the first prize, but £250 was divided among four of the competitors as an encouragement. Then, for some years, interest in this subject languished, and public encouragement ceased. In 1883, however, a description appeared in *The Australasian* of a machine that was working in California. Both State and public interest were again aroused, prizes were offered to successful inventors by the Victorian Government, and from that time improvements have gradually been made in the construction and efficiency of the machines.

The difference between Australian methods and those of other lands may be briefly set out. The reaper and binder cuts and binds the crop into sheaves, to be threshed later by a threshing machine; the stripper gathers the stalks into a comb, the heads are stripped off by beaters, and the grain threshed from the heads by winnowers at some later date; the harvester strips off the heads, as with the stripper, but does the threshing at the same time, and delivers the cleaned grain into a hopper or into bags; and the header of California cuts, threshes, and cleans the crop at one operation, but to win the short-strawed grain, takes in a lot of lengthy straw, as it cuts everything above the level of the knife, like a reaper and binder. This machine takes from 24 to 30 mules to draw it, and is cumbersome. While the Commonwealth possesses a variety of good strippers and harvesters, it is an axiom of implement manufacturers never to rest content with the present machine, but ever to aim at improvement. The aims which machinery firms

have had before them are :—Cutting a larger area in a given time ; the lessening of the draught ; prevention of grain shelling ; harvesting "lodged" and dirty crops ; an early, late, and damp weather worker, which will not drag out the plants by the roots ; at the same time a machine which will turn out as good a sample of grain as the best of the present harvesters. The reaper-thresher, the latest improvement, seems to have gone a long way towards reaching this goal.

A large amount of work has been done in breeding wheats which are resistant of diseases ; strong in the straw and hard, to stand up against the hot winds which break down or thresh out weaker varieties ; prolific and yielding grain of high quality. The first systematic movement towards improvement of wheats was made by Victoria, where, in 1890, a conference of experts from various States was held to devise means for fighting "rust" in wheat, which had caused serious losses in all the States during preceding years. Other conferences followed, until eventually it was recognised that this was only one of many problems confronting the wheat-grower. It was through these conferences that other States learned of the research work which William Farrer had been carrying on since 1882 in New South Wales, and his example stimulated others to carry on cross-breeding and selection on parallel lines. In "Federation" he produced a wheat which is familiar to every farmer in Australia, and which has increased the yields of the mainland States by many thousands of bushels. "Federation" possesses in a strong degree the qualities of prolificacy, shortness and strength of straw, and power of holding its grain. The trend of experiments now is to produce wheat of high milling qualities, which will raise the value of Australian flour in the home market, though at the present time our wheats from their whiteness are used chiefly to blend with the yellower wheats of other lands.

For many years now, there have been scattered through the States a number of men who have devoted their lives to the breeding of wheat and to the study of plant disease. Their labours, undertaken from a love of science and with no hope of monetary gain, should still further assure the success of this industry, and eventually bring Australia to the front rank as a wheat producing country.

Farmers show a commendable care in the seed which they sow, generally using cleaned and graded grain, while they watch carefully the work of the different experiment stations, and eagerly buy any new varieties of promise.

In the three eastern wheat-growing States of the mainland, well-equipped experiment stations are carrying on fine work, as are also a number of private investigators.

To return to cropping methods, farmers are working steadily towards a rotation of crops which will maintain the land in good heart. It is recognised that the system of bare fallowing must eventually exhaust the soil. The old rotation has been bare fallow, wheat, bare fallow ; or bare fallow, wheat, oats ; or bare fallow, wheat, oats, pasture—the long stubble left by the stripper being burnt off when one crop follows another ; or if, after wheat, the land is left in pasture, the straw is worked back into the ground by the stock. While burning off the stubble is wasteful of humus, it serves to clean the ground of insect pests and weeds. Oats should follow wheat as often as possible to prevent the attacks of the disease "take-all," even when a fallow

intervenes. But oats are not as widely grown as wheat, because the local market is soon supplied, and the export trade is not large. The necessity for providing a fodder crop for sheep has led to rape being sown in the autumn on the stubble, the sheep droppings, roots, and stalks, when turned under, helping to replenish the soil. Far-seeing farmers have recognised that a leguminous crop is necessary, and peas are now sown, being generally used as a fodder crop and the residue being turned under for green manure.

The rotation most likely to be adopted in the near future, at any rate wherever a 15-in. rainfall can be depended upon, is bare fallow, wheat, oats, rape; or bare fallow, wheat, oats, peas. The difficulty in adopting a regular rotation is that oats and fodder crops cannot be grown as profitably as wheat.

One of the most striking features about wheat-growing of late years is the extension of the safe areas westward in New South Wales, by the adoption of fallowing, systematic working of paddocks to check weed growth, and the use of artificial manures.

It is difficult to state the average yields of cereals to convey definite information, because they differ so much with locality and with seasons. In Tasmania, 50 or 60 bushels to the acre are not uncommon; while on the mainland, anything over 30 bushels is a good return.

In the Mallee districts of Victoria and South Australia, with a limited rainfall, lighter yields are usually experienced; but the cheapness of the land, which is easily cleared for the plough by rolling down and burning off the scrub and then ploughing with stump-jump ploughs, enables wheat-growing to be profitably carried on. These lands and the subdivided sheep country of New South Wales offer perhaps the best prospects for mixed farming in the eastern States. The best Mallee land is obtainable at £1 per acre on extended terms, which in South Australia are extremely liberal, as for four years no instalments are payable, and for the next two years the interest due is at a very low rate. Contrast this with the price of mixed-farming land in the older districts, where from £6 to £8 per acre is common, while in picked districts £12 to £15 per acre was realized a couple of years ago, though those prices have since declined. In all the States, land selection can be made on reasonable terms; and in Queensland and Western Australia, free grants are made to overseas settlers.

Some idea of the importance of wheat-growing to the Commonwealth may be grasped by noticing that for the 1911–12 season, nearly 72 million bushels of wheat were produced, the returns for 1910–11 being over 95 million bushels, and for 1909–10 nearly 90½ million bushels. The average yields for those seasons in the same order were 9·6, 12·9, and 13·7 bushels; and for 10 years which include the great drought of 1902–3, the average is 10·48 bushels per acre.

A burning question with wheat-growers at the present day is the handling of the harvest from fields to sea-board. A few years ago legislation compelled the use of three-bushel bags instead of four-bushel. These bags, are carted to the station as soon as harvest is over, the results being that the goods platforms are loaded in a few weeks to their full carrying capacity, the overflow being stacked in the station yard, there to remain, possibly for months, before the railways can deal with them. This means considerable

loss from mice, and, in some years, from rain as platforms and yards are quite unprotected from the weather. The fact that new bags must be purchased every year, is also a considerable tax on the producer. For these reasons handling in bulk has the strong support of all country people, and a definite movement in this direction seems about to be made. A Royal Commission in Victoria has just reported in favour of bulk-handling, and New South Wales has brought an engineer from the United States to devise a workable scheme for that State, and other States are also studying the best means for dealing with the situation.

The output of oats depends to a considerable extent on the prices ruling for the previous season. Oats were very cheap for years, and many ceased to grow them. The production has varied during the last eight years from 9 million bushels to 16 million bushels, and the average over the whole period is 20¼ bushels per acre. The Algerian oat is the principal variety grown. Oats are grown largely for hay; and in some districts wheat and oats mixed are sown for this purpose. Victoria produces nearly three times the quantity of oats grown by any other State, Tasmania coming second, with New South Wales and South Australia about equal. Tasmania has the highest average—30 bushels per acre.

With barley, the difference in price between a bright sample and a discoloured one is so great that the crop is not grown to any very large extent, the highest production during ten years having been 2¾ million bushels in 1908–9, and the average for ten years, 18·83 bushels per acre. Victoria and South Australia are the largest producers, though Tasmania has again the highest average—24 bushels per acre.

Maize-growing for grain is very successfully carried on in the northern rivers district of New South Wales, in Gippsland (Victoria) and in Queensland. Victoria can claim some of the highest yields in the world, returns of over 100 bushels per acre being by no means uncommon. A great drawback to the industry is the want of communication. The rivers are usually un-navigable on account of sand bars at their mouths, and in many cases the maize is marketed "on the hoof" by using it as pig feed. As a fodder crop, maize is one of the most common, yielding a great bulk of material in the coastal districts, under the natural rainfall, and inland, under irrigation. Not much attention has been given by the Agricultural Departments of the States to the selection of maize seed, or the breeding of varieties to suit varying local conditions. Most of the leading American varieties are grown, and considerable enterprise has been shown by private individuals in raising pure seed.

Both in point of acreage under crop and total production, New South Wales usually holds pride of place, though Queensland is very nearly equal, while Victoria comes a long way behind. In yield per acre, on the other hand, Victoria is a long way ahead, having, for ten years, produced an average of 55 bushels per acre, the highest during that period being in 1903–4, when 76½ bushels per acre was the amount recorded. The average for the whole Commonwealth for the ten years from 1902 to 1912 is 26·84 bushels per acre.

The production of hay in the Commonwealth is intimately associated with the cultivation of cereals, as the great bulk of this fodder is composed of wheat or oats. Formerly, Victoria exported a large quantity to New South Wales

and Queensland, but, the former State now grows sufficient for its own requirements, except in times of drought. As a rule, the farmer cuts his crop for hay or keeps it for grain, whichever promises to bring in the larger gain; but, in the cooler districts, cereals are often sown for hay alone, and a mixture of wheat and oats often being used for the purpose. In these districts special hay wheats are sown, but Algerian oats are employed everywhere. The colour, smell, and amount of grain in the head are factors in determining the value of hay, the yields of which in the hay districts are from 2 to 3 tons per acre in good years. In the wheat districts, 2 tons per acre is a good hay crop, and the average for the Commonwealth for ten years is only $1\frac{1}{4}$ tons per acre. Victoria has a production of a little over one million tons to her credit for 1911–12. In the early days, hay was made from the natural pasture grasses, but these are now seldom used for this purpose.

(b) Lucerne Hay.

With the expansion of dairying, and, especially since the irrigation settlements in the various States have been founded, lucerne is largely used for making into hay. The usual and most sound practice is to grow enough of this fodder to supply the needs of the farm; but, during a dry period in the autumn of 1912, a demand sprang up for this article, and many sold off their stock in order to grow hay. The next season being a good one, lucerne hay was practically unsaleable. A number of sheep-owners in the Riverina, taught by the experience of past dry years, make immense stacks of lucerne hay from irrigated paddocks, which are kept in reserve for periods of scarcity. From four to six cuttings of lucerne per season can be counted on from irrigated land, and in districts where a good rainfall is assured, the yield at each cutting varies from 1 to 2 tons per acre. The best seed is grown in the Commonwealth and comes from the Hunter River district, in New South Wales, but a fair quantity is imported. Sowing is done in either spring or autumn, but the former is considered a better time, since a clean seed-bed can then be more certainly assured.

(c) Tobacco.

Of the States New South Wales now grows the greatest amount of tobacco, the industry in Victoria being confined mainly to Chinese, many of whom are working on shares with white land-owners. The rich alluvial flats are found very suitable for producing the finest leaf. About 1,500 acres are under cultivation in New South Wales, about half this amount in Queensland, and one-third in Victoria. The average yield for the Commonwealth is about $7\frac{3}{4}$ cwt. per acre. Though a payable enough crop, the incessant labour required in a land where labour is dear and scarce, has led to many abandoning it.

(d) Ensilage.

One cannot leave the subject of cropping without further reference to ensilage, a fodder which should especially appeal to Australian farmers, since the conditions lend themselves so readily to the preservation of fodder in this form, and at the same time demand conservation of supplies for the safety of the stock. It is essentially a land of bounteous seasons and of dry ones. In the good years thousands of tons of fodder go to waste. In the dry seasons,

thousands of cattle and sheep die, not so much from want of fodder, for often dry feed is available, but through impaction, which a succulent fodder like ensilage would prevent.

Unfortunately, statistics show that the quantity of ensilage made each year is not increasing, thus proving that the farming community still fail as a class to appreciate the true value of this form of stock food.

Provident farmers adopt the practice of sowing in the early autumn a mixed fodder crop of rye, peas, vetches, and barley. This is cut in the spring, which prevents the weeds going to seed. The silos are constructed above ground and the material is first chaffed, and then elevated or forced up into the silo by means of a blower. To consolidate the green fodder, it is trodden down during the filling process, particularly round the edges; and, as a rule, unless it is to be used at once, is covered with straw-chaff or bags and weighted. Where a surplus amount of spring grass is available, it is occasionally converted into ensilage, being put straight into the silo, without chaffing. Later in the year, about October, summer fodder crops are sown—maize, sorghum, millet, etc., and these are converted into ensilage in the autumn.

(e) Root Crops.

The two main root crops are potatoes and onions, though turnips, mangolds, etc., are grown in the cool districts. Victoria is the largest producer of potatoes, heading the list both in area under crop and in output. New South Wales comes next in point of area, but is closely pushed by Tasmania in output with half the area under crop. For many years, Tasmania supplied all the States except Victoria with most of their tubers; but the ravages of potato-blight reduced the output, and induced farmers to undertake a systematic rotation instead of exhausting their land with the one crop. Victorian crops also suffered severely from this disease, but, by spraying and resting the ground, this trouble has been overcome. When the blight was rampant, a number of growers dropped out, and, in consequence, in 1912, potatoes were at famine prices. Those who had continued growing them, having clean, good crops, the result of assiduous work, received handsome rewards. Rich potato land sells at £100 or more per acre, and the rental often reaches from £4 to £6 per acre. When prices have exceeded £10 per ton, cases have been reported where the purchase money has been recouped in one season. After a scarcity, every farmer with a good piece of land in a suitable locality puts in potatoes, with the consequence that, in the following season, prices are hardly payable. As an instance, the price last year, was for months not lower than £12 per ton, reaching much higher for a short time, whereas this year, the choicest varieties can be purchased for £4. A definite rotation, in these districts, will not only correct this great irregularity of prices, but also eradicate diseases and maintain the fertility of the soil.

The production for the Commonwealth for 1911–12 was 391,489 tons, a considerable decrease from the yield of 1906–7, when it was 507,153 tons. Tasmania was responsible for a deficit of no less than 120,000 tons. The total yields in 1911–12 were—Victoria, 119,092 tons; New South Wales, 75,040 tons; Tasmania, 62,164 tons. The averages for the principal States for ten seasons are—Tasmania, 3·94 tons per acre; Victoria, 2·8 tons; South

Australia, 2·7 tons; New South Wales, 2·35 tons; Western Australia has an average of 3 tons per acre, but her highest annual production is only a little over 9,000 tons.

In onions, the production of Victoria only is worth mentioning. Her largest output was in 1910–11, when 37,484 tons were grown, with an average of a little over 6 tons per acre. Like potatoes, onions fluctuate very much in price; and while, in some years, the cost price of the land can be earned in one season, in others they have been a drug in the market. Last year prices were £17 and over per ton, whereas this year £6 is a usual figure. As the average yield for ten years is over 5 tons per acre, some idea may be gathered of the returns; but it must be remembered that the work of preparing the ground and keeping the crop clean is very expensive, while the crop is a delicate one to handle.

(f) Sugar.

Queensland and New South Wales are the only States which grow sugar-cane, the former producing about 90 per cent. of the total. For 1911–12 the output for Queensland was 1,534,451 tons of cane, with an average of 16 tons per acre, which is very nearly the average for the last ten years. New South Wales has an average of 22·64 tons per acre for the same period.

It is difficult for any one not a resident of sugar-cane districts to understand the situation of the industry. Formerly, the work was carried on by black labour recruited from the islands under strict Government supervision. The "White Australia" policy disposed of this system, and as a consequence, the proportion of sugar produced by coloured labour declined from 68 per cent. of the total for 1902–3 to 6 per cent. in 1911–12. As a recompense to the growers, the Commonwealth Government passed a Sugar Bounty Act, giving a bounty on all cane of a certain quality produced by white labour. In 1912, however, two Acts were passed, one abolishing the bounty and the other repealing the Sugar Excise Act, under which an excise duty of £4 per ton on manufactured sugar had been collected. These Acts did not, however, come into force till the following year (1913). It was stated at the time that the Queensland Government intended to take over the matter, and to deal with the question of wages and conditions of labour.

In Victoria, the manufacture of beet sugar is carried on; but the industry is in anything but a flourishing condition, owing to the difficulty in getting a sufficient quantity of land under this crop to justify the working of the machinery. In 1911–12, there were in Victoria 752 acres sown with sugar-beet, which yielded 3,974 tons, or a little over 5 tons per acre. Some years ago, the Government of the day built a sugar-beet factory at Maffra, in Gippsland, equipped it with most expensive machinery, and obtained experts from Germany to superintend the manufacture. Owing to the lack of support on the part of growers, it was closed down for years, and re-opened again in 1910. At this time, land which had been resumed by the State for closer settlement purposes was disposed of with a proviso that a certain number of acres should be devoted to the growth of sugar beets. The constant labour required to keep the crops clean has rendered this branch of farming, to put it mildly, less remunerative than many others; and growers are

endeavouring to have the compulsory area reduced. There is also a bounty on beet sugar, the amount being 6s. per ton on beet giving 10 per cent of sugar. During 1911–12, bounty was paid on 7,481 tons.

5. Viticulture.

The cultivation of the vine was commenced at an early date of Commonwealth history by foreigners who had emigrated from the wine-making countries of Europe. They found the climate even more suitable than their own for certain classes of wine, and the soil as fertile. From these men, others procured cuttings or rooted vines and embarked in the industry, wine making being carried on principally. With rude appliances and without any of the necessary scientific knowledge, they produced a lot of rough, coarse wine, so that "Australian wine" was a by-word in the Colonies.

A few vignerons in Victoria and South Australia, however, having more capital and experience, succeeded in making wine of fair quality. This gradually improved, and a great impetus was given to the industry in Victoria in the nineties by the voting of a bonus, in instalments, for every acre planted. This induced a number of farmers and novices who were not at all suited for it to undertake the work. As a consequence, a great quantity of inferior and almost unmarketable wine was produced, so that when the bonuses ceased, the greater number of these inexperienced growers retired, the remainder struggling on, until, a few years later, the appearance of phylloxera compelled them also to abandon the industry.

During this time those with large capital sunk in the trade and making good wine, were pushing their way into the English market, aiming ever at making a wine for export and not for home consumption. Aided by the disappearance of the bulk of coarse, inferior wines, an export trade of considerable dimensions has eventually sprung up, mainly in full-bodied, dry red wines, which are used for blending. It is contended that these err on the side of strength, and lack the velvety smoothness which should characterize a first-quality product. However that may be, young wine can now be sold at a higher price than could the matured article a few years ago. A promising wine, at twelve months, will bring 2s. per gallon, and small growers are making a good profit at this price, as yields of from 300 to 500 gallons per acre can be secured. This, briefly, has been the experience in Victoria.

In South Australia, the market has been steadier, and the quality more uniformly good, because there has not been, at any time, a great rush into the industry by men unfitted for the work. In New South Wales, the experience has been somewhat similar to that of Victoria, on a smaller scale.

The output of wine for the Commonwealth is about 5 million gallons, of which South Australia supplies about 3 million, Victoria, 1 million, New South Wales, 800,000, and Western Australia, 150,000 gallons.

The spread of phylloxera in Victoria and New South Wales, while it accelerated the retirement of incompetent growers, has nevertheless inflicted serious damage on the industry, and vigorous efforts are being made to combat it. A number of stations for growing resistant vines have been established by the State Governments, and cuttings or grafted rootlings are distributed to growers at merely the cost of production.

The raisin and currant industry may be said to have started with the establishment of the irrigation settlements at Mildura (Victoria) and Renmark (South Australia), on the Murray River. In the early nineties, the product began to make itself felt on the market, which, from its superiority over the imported article in cleanliness and flavour, it soon captured There was a danger then that prices would fall below a profitable margin: but co-operation of the growers prevented this by determining to export the surplus after the home market had been supplied. This has been done for some years now, and comfortable incomes are realized from small blocks planted with vines.

The total production of the Commonwealth in raisins and currants was in 1911-12, 234,898 cwt., of which Victoria manufactured 119,713 cwt. and South Australia 81,346 cwt.

All five mainland States raise table grapes, principally for Commonwealth consumption. Latterly, Western Australia has been making shipments of fresh grapes to England, and with a satisfactory measure of success. In the eastern States, the varieties most suitable for this purpose, such as Ohanez, Purple Cornichon, Flame Tokay, have been planted and are now coming into bearing, so that an extension of the export trade may be looked for.

6. Fruit-growing.

When we remember to what extent this industry depends on the export trade, Tasmania undoubtedly deserves the highest credit for her enterprise in building up a great export trade in apples. Practically unaided by State assistance in any form, the apple-growers of the island State despatched trial shipments, and paid the expenses of growers to watch the cargo during the voyage and to supervise its distribution in London.

Contrast these tentative shipments in the eighties with the apple season to-day, during which a dozen or more large ocean steamers leave the port of Hobart alone, with fruit (mainly apples) for cargo, two or three boats being occasionally berthed alongside the wharves at the same time.

The shipment last season from Hobart comprised 465,193 cases for the United Kingdom; 15,625 for Germany; 1,649 for Sweden and Denmark; and 49,720 for South America; or 522,188 cases in all, as against 807,510 for the previous season. Victoria despatches only about half this quantity; but the industry is a growing one in all the States.

The excellent machinery now manufactured for refrigerating purposes has rendered the shipment of such soft fruits as pears a success; and with the extension of markets to other British ports than London, and to Europe, Canada, and other parts of the world, the industry may be regarded as only in its infancy.

It is claimed that, by pre-cooling, any variety of fruit may be carried with safety, and, certainly, the results of the experimental shipments of pre-cooled fruit seem to justify the statement. At the present time efforts are being made to secure better arrangements with the shipping companies; and it is hoped as the result of the inquiries of a Commonwealth Royal Commission, that the export trade will be placed on a more satisfactory footing in every way.

The small fruits do remarkably well in the cooler districts of the southern States, and particularly in Tasmania; but, as these do not lend themselves to exportation, the trade is limited.

7. Irrigation and Artesian Water.

The name of Mildura, in North-western Victoria, naturally associates itself in the mind with the earliest efforts of irrigation in settlements. Individual irrigation had been carried on previously, but little had been heard publicly of the suitability of the Australian soil, climate, and rivers for extensive watering until Messrs. Chaffey Bros. obtained a concession from the Victorian Government and started work on the Murray River in 1884. From 1887 to 1895 the management was carried on by Messrs. Chaffey Bros. Co. Ltd., when it was taken over by the First Mildura Irrigation Trust. Though the settlement passed through many hard times in its early years, those who survived are now in a very prosperous position. Various difficulties were at first met with—salt in the soil, inexperience in the suitable varieties of trees and vines, insufficient pumping power, etc.; but, one by one, these difficulties were overcome.

The main industries now are—currants, raisins, prunes, and other dried fruits. Some idea of the prosperity of this, the largest irrigation settlement in the Commonwealth, may be gathered from the fact that in 1911 (Census) there were over 6,000 inhabitants and over 12,000 acres under cultivation.

Renmark, also on the Murray, but in South Australia, was established a little later than Mildura. Its development was conducted more slowly; and it, therefore, reaped a certain amount of benefit from the experience of the other settlement. Renmark has a population of 2,000, with 5,200 acres under cultivation, and an average production of about £100,000 per annum.

As the result of an irrigation campaign, conducted by Mr. Alfred Deakin, who had visited India and America in search of information, various water trusts were established in the northern areas of Victoria in the late eighties and early nineties, many of them, however, only for watering stock. The largest of these, in the Goulburn Valley, also included a fruit-growing settlement at Ardmona, while a large extent of country was taken up to irrigate lucerne for fattening stock. Eventually the State wiped off most of the indebtedness of these trusts; and, as the water was supplied very cheaply, prosperity in these areas became general.

A new impetus was given to irrigation in Victoria during the early years of this century. In 1906, all State waterworks were vested in the State Rivers and Water Supply Commission of three members, and this Commission eventually took over the duties of the whole Water Supply Department, and, at a later date, the control of irrigation lands, which previously were vested in the Closer Settlement Board. This Board has done good work in concentrating the settlers on all new areas, and so lessening the cost of supplying water.

Under the Closer Settlement Act a number of irrigable estates were bought up from private owners, subdivided, and settled mainly from overseas, though Australians have also taken up some of the blocks.

Where sufficient capital was available, and the settlers were hard-working, good progress has been made, and there is reasonable prospect of success. On blocks of 50 acres and upwards, dairying is carried on by means of lucerne and fodder crops, while, at the same time, small areas are planted with fruit trees, the dairying operations bringing in ready money during the time that the fruit trees are coming into bearing.

As with all colonies of this nature, a good deal of tribulation will be experienced before the settlers "make good." One great drawback is the absence of markets in which to dispose of small products, such as vegetables, tomatoes, etc.; but, when once the orchards are in bearing, with the ever-extending overseas markets, and the knowledge gained from the experience of the pioneers in the fruit industry, a comfortable living should be made off these small areas.

It is calculated that without taking into consideration waterworks constructed for the supply of cities and towns, the various works vested in the Commission have a capital debit to the State of over £4,000,000.

At the present time, a project is on foot for the construction of a storage reservoir near the source of the River Goulburn, which, if undertaken, will be perhaps the largest in the world. It is estimated that it will have a storage capacity of 60,000 million cubic feet, and some conception of its size may be obtained by comparing it with the Assouan Dam in Egypt, which holds 35,840 million feet.

New South Wales has constructed a large dam (Burrinjuck), across the channel of the Murrumbidgee River, with an estimated capacity of 33,630 million cubic feet of water, to be stored from the winter rains. The water will be run down the Murrumbidgee for 200 miles to the Berembed Weir, from which it will be carried by gravitation to the irrigation settlements. It will command 200,000 acres of first class land and 360,000 acres of second class land, which is estimated to support eventually 50,000 people. At present a number of settlers are on blocks, but have only just commenced operations. When the "Murray Waters" question is settled between the States of New South Wales, Victoria, and South Australia, far more use will be made of the great waterway for irrigation purposes.

One cannot leave the subject of water supply in connexion with agriculture without some reference to the artesian supplies which have rendered so much of the interior country habitable and possible for stock raising. The artesian area has a width of about 900 miles in the latitude of Brisbane, stretching from Toowoomba to the overland telegraph line. Bourke marks in a general way its southern limit, and in the north it runs to the Gulf of Carpentaria, stretching from Cape York to west of the Gregory River. A strip of the coast line in Western Australia is also recognised as artesian.

Large sums of money have been spent by the Governments of most of the States in boring on stock routes while a considerable amount of bores have been put down by private enterprise. The water obtained is chiefly used for stock, being too highly charged with carbonate of soda for irrigation purposes, though, to a limited extent, it is used for this purpose also. The yearly extension of the boundary of artesian water is adding more and more "safe" territory to the list. There are nearly 3,000

bores in existence, both private and public. The deepest bore is over 5,000 feet; and the largest supply is from one in Queensland, which gives about $4\frac{1}{2}$ million gallons per day.

In the north-west of Victoria and in South Australia is a sub-artesian supply, the water from which has only reached the surface in three bores; but, in others, it comes within 80 feet and is pumped up for use. This simplifies the settlement of the Mallee districts, which are rapidly being converted into wheat-growing areas. Water is obtained from wells in most of the districts bordering on the Murray River, even for 20 to 30 miles back from the frontage. These are from 80 feet to 100 feet deep, and the water which is often slightly brackish is pumped to the surface by windmills.

8. Labour Conditions.

Labour conditions cannot be regarded as quite satisfactory; but there is much to be said on both sides. Skilled labour is practically unprocurable, because a capable man can soon save enough to begin farming on his own account, and invariably does so, every inducement being offered in the shape of cheap land on extended terms, share-farming, etc. The consequence is that at harvest-time, the only labour available is not thoroughly efficient, though the demand is great and the pay high. In the dairying districts, there is constant scarcity of milkers; and many are reducing their herds to the number which can be handled by their own family with milking machines, or else letting part of their farms to "share" men. In cropping, the number of acres put in by each farmer is likely to be reduced, particularly as this will enable more sheep to be carried, and a better system of rotation pursued. Larger implements and teams are also being used to curtail the employment of labour. The policy of irrigation, however, now being carried out by the various Governments should have the effect of relieving the situation to a certain extent, provided that the right class of immigrant is secured. Many of the small selectors will gladly put in a few weeks at harvesting or shearing, during the clearing of their own land.

A few acres of land, with a cottage, a cow, pigs, and fowls, possibly a certain amount of crop on shares, with a security of tenure, should prove a good investment of capital for land-seekers; and should suit those who prefer the advantages of civilization to "roughing it" on a selection of their own.

The position at the present time is as follows:—The Labourers Union has drawn up a "log" of prices and hours of labour for every branch of the great producing industry, and demands its acceptance by farmers, who would be agreeable in many instances, to the rates demanded, if they could obtain efficient workmen. The fixed hours they regard as impracticable. Even should these schedules become law, through the Arbitration Court, it will be necessary to compel every farmer to carry on his business in the same manner as at present, before the working class will materially benefit, and the question is raised whether the industries requiring the most labour will be curtailed in favour of branches like grazing, in which very little labour is required.

The pastoral industry, about twelve months ago, emerged from a protracted suit before the Arbitration Court, whereby all conditions of labour and living are fixed.

It has been said that little has been done by farmers as a body to make the conditions of living such as will induce labourers to remain for any length of time. The food is invariably good and plentiful, and often partaken with the farmer's family; but the "men's hut" with its bunks, for which the occupants must find the bedding, still represents the only shelter for labour. On some farms, in the newer districts, conditions are worse, and men are left to find sleeping accommodation during harvest in chaff house or machinery shed. Farmers themselves, having "roughed it" as selectors in their early years, do not give sufficient attention to this point, and have not realized that conditions are altered. Pastoralists, on the other hand, provide ample and good accommodation for shearers; and the schedule determined by the Arbitration Court sets forth in precise terms the amount of sleeping and living space necessary for each man.

9. Agricultural Education.

In some respects, the Commonwealth can point the way to the world in her system of agricultural education. For instance, there is an agitation in Great Britain just now to make the work at their institutions more practical, so that students shall take part in every farm operation. This has been a fundamental principle in Australia from the beginning. Colleges have been established in all the States, except Western Australia and Tasmania, and in the latter State one is in process of foundation.

With the exception of Victoria, where they are under the control of a Council of Agricultural Education, the colleges are directly under the different departments of Agriculture, and are financed by State grants and their sale of produce. The fees are small at all the colleges, varying from £20 to £35 per annum, so that the sons of men in every class of society can take advantage of the education offered.

The object in view is to turn out young men who will go on the land; and the curriculum is drawn up with this purpose. The methods adopted vary to some extent at the several colleges, but, in general, class-days and work-days alternate, the whole body of students being divided into two classes, one of which is working and the other in class on the same day. The farm work is apportioned according to the standing of the student, senior students being in charge of teams—ploughing, sowing, or harvesting, or at blacksmith's work, carpentry, shearing, separating, etc., according to the season of the year, junior students are occupied with milking, hoeing, carting, stablework, fencing, and the hundred and one odd pieces of work to be found on a farm. The work-list is usually changed each week, so that each student gets a fair share of the work. The class work embraces instruction in agricultural chemistry, soil physics, farm engineering, botany, entomology, geology, and farm accounts, as well as the subjects pertaining to an ordinary commercial education. From the distribution of the farm work, it can be gathered that great advantages are attached to limiting the number of students, so that each may gain that knowledge which only practice can give.

The course varies from two to three years, and the ages of students range from fifteen years upwards, the average being about eighteen.

In Victoria are a number of agricultural high schools designed to act as stepping-stones between the State school and the agricultural college. The various experimental farms in New South Wales provide accommodation for students, whose time is mainly given to practical work, and in Western Australia similar provision has been made. A Chair of Agriculture has been established in New South Wales and Victoria, and the colleges are affiliated with the University, undergraduates who take the course of agricultural science being required to do a certain amount of field work at the agricultural college.

Instruction classes for those already on the land are conducted in nearly every State, but in this respect Australia falls short of the standard realized in the United States. This to a great extent is due to her scattered population and to the fact that there is no "off" season in Australia, when farm work cannot be followed. The earliest students who passed through the colleges are now beginning to occupy prominent positions in the agricultural world, and the training is better appreciated by the public; but farmers are not availing themselves of the agricultural high schools to the extent hoped for nor have they ever taken full advantage of the colleges for their sons. The majority of students, of whom the total according to the latest return is 630, comes from the professional and mercantile classes. Most of the students are too young, after finishing a college course, to undertake farming for themselves, they therefore pursue the wiser plan of gaining further experience on good farms, where the handling of men and the business of buying and selling can be learned.

10. Land Tenure.

It is not possible to cover in a few paragraphs the systems of the various States, which differ considerably. They may, however, be considered under the broad headings of leases or licences, conditional purchases, free grants, and cash purchases.

Leases are generally for pastoral purposes, the lessees being the pioneers who take up new country, which they usually improve considerably before being ousted by the selector. The immense stations containing hundreds of thousands of acres are now confined to the interior and northern parts of the Commonwealth, the rents for which are only a few shillings per acre. There are, however, large leasehold blocks in all the States, usually of rough land not fit for cultivation, and devoted to sheep or cattle. Lessees are usually allowed to select so many acres out of their leased land.

The conditional purchase is the usual method of acquiring land in all the States. The age limit at which land may be secured varies from sixteen to eighteen years; the area, from 200 acres to 2,500 acres, according to locality or conditions of the Land Act; and the price, from a few shillings to £1 per acre. As a rule, the survey fee and some deposit must be paid at the beginning, the full amount being paid off by yearly instalments, in different periods ranging up to 40 years. In some cases no payments are required for several years; and, in all, the rate of interest is very low, principal and interest together amounting to not more than 6 or 7 per cent. Improvements must be carried out to a certain amount each year, and residence for so many months in the year is usually insisted upon.

The holder of a block on conditional purchase is termed, in all the States, a selector. As a rule, at first, only a licence to occupy is given ; then, when the terms have all been faithfuly observed for several years, a lease is issued which is negotiable. At any time after the issue of the lease, by paying the remainder of the purchase money in cash, a grant may be obtained.

These are the terms under which the great bulk of the land in Australia has been alienated. The maximum area in the early days was 320 acres, but it is noticeable that very few farms in the wheat-growing districts are as small as this—1,000 acres being more nearly the average holding. In the heavily timbered coastal districts, the smaller area has proved quite sufficient, as the land is rich, the rainfall good, and the cost of clearing very heavy. In New South Wales, leased land in the western districts is being resumed and subdivided for selection, while in Victoria and South Australia, settlement is now taking place mainly in the Mallee lands of the north, which can be cheaply cleared for the plough by rolling down the scrub and then burning it off. Queensland and Western Australia have greater areas of Crown lands unalienated, and are attracting settlers from all the States and from overseas by their liberal offers.

Closer Settlement Acts have been passed in every State, by means of which estates have been purchased in settled districts, subdivided, and disposed of on extended terms The earliest subdivisions, which were in Victoria, turned out very successful ; and enabled many men with small capital to obtain farms. Latterly, most of the effort has been directed to settling those estates which are commanded by irrigation channels. Provision has been made for loans to settlers in proportion to the amount of capital sunk in improvements.

In every State free grants are made for educational, religious, or recreation purposes, but only in Queensland and Western Australia are they made for settlement. In Queensland the maximum area which may be selected as a free homestead is 160 acres. The selector must reside on the block for five years and must fence it in or make improvements of equal value.

In cash purchases from the Crown, as a rule, the land must be put up at public auction, an upset price being fixed. In all the States are credit systems under which farmers can obtain advances on easy terms on the value of their land and improvements.

11. Forestry.

This subject is closely connected with land settlement, and most deplorable has been the ruthless destruction of valuable timber in every State, during the process of agricultural development. Forests have disappeared before the axe and fire of the selectors, and now, in the settled districts, a great scarcity of timber for fencing, firewood, and building purposes is noticeable.

Forest reserves were made early in the history of Australia, but these were mainly to preserve timber for the use of the mining industry.

South Australia has had for many years a well-organized Forestry Department, which, in many respects, has been an example to the rest of the Commonwealth. Of late years, greater attention has been paid to the preservation of existing timber and the replanting of areas with the best of

native and foreign timbers. All the States have established State nurseries and plantations, from which are distributed, at the cost of the labour in packing, to public bodies and farmers, trees of native woods, such as the many eucalypts, acacias, and native pines, as well as foreign trees, mainly pines and pepper-trees, while a few oaks, willows, etc., have also been grown. In this way encouragement is given to the growth of shelter belts, the thinning of which affords a useful amount of timber.

In Victoria has been established a Forestry School, where subjects pertaining to this important industry are taught, as well as the practice in the growth and improvement of plantations and forests, and the employment of timber. There is also a course in forestry at the Adelaide School of Mines.

Of late an increased interest in forestry has been evinced in all the States, due to conferences held in Sydney and Melbourne: and it is hoped that further wanton destruction will be prevented, and that replanting will repair the damage which would eventually have so injurious an effect on the climate and soil of the Commonwealth.

CHAPTER X.

MINING FIELDS OF AUSTRALIA.

By E. F. Pittman, A.R.S.M., Government Geologist of New South Wales, and A. Gibb Maitland, F.G.S., Government Geologist of Western Australia.

SYNOPSIS.

1. New South Wales.

Since the discovery of payable gold by Hargraves at the junction of Lewis Ponds and Summer Hill Creek, in 1851, mining has been one of the most important factors in the prosperity of New South Wales. It was the easily-won alluvial gold which first attracted population to our shores, but subsequent prospecting revealed the occurrence of rich deposits of almost all the known useful metals and minerals, and the permanence of the Mining Industry in the mother State of Australia is now assured.

Coal.—Unquestionably the most important of the New South Wales' mineral assets is her coal, and in regard to both its quality and quantity she has been most liberally endowed by Nature.

Coal seams of several geological ages have been found in the State, but it is only from rocks of the Permo-Carboniferous period that coal of commercial value is obtained.

The Permo-Carboniferous System has been classified as follows, in descending order :—

	Thickness in Feet.
1. Upper or Newcastle Coal Measures, containing twelve seams In the aggregate they contain 35 to 40 feet of workable coal . ..	1.400 to 1,500
2. Dempsey series ; freshwater beds containing no coal	2,200
3. Middle, or Tomago, or East Maitland Coal Measures, containing six seams of coal, varying from 3 to 7 feet in thickness. In the aggregate they contain 18 feet of workable coal	500 to 1.800
4. Upper Marine Series	5,000 to 6,400
5. Lower, or Greta Coal Measures, containing an aggregate of about 20 feet of coal	100 to 300
6 Lower Marine Series	4,800
	17,000

There are four important coal-fields in New South Wales, viz., the Maitland, the Newcastle, the Illawarra or Southern, and the Lithgow or Western. In the Maitland field the Greta and also the Tomago coal seams are worked, while in the other three fields the coal is obtained from the Upper or Newcastle Measures.

The Greta Coal Measures never exceed 300 feet in thickness, nevertheless they contain two seams of splendid coal, viz., the Upper Seam from 14 to 32 feet in thickness, and the Lower Seam from 3 to 11 feet in thickness. The quality of this coal is superior to that of any other coal in Australia, and it is especially suitable for household and gas-making purposes, and also for steam raising. Eleven collieries are at work on this coal between Maitland and Cessnock, a distance of 15 miles, and their aggregate output for the year 1912 was 3,074,598 tons.

The average composition of the coal from the Greta Coal Measures, as calculated from the analyses of 31 representative samples, is as follows:—

Hygroscopic moisture .. .	1·89
Volatile Hydrocarbons	41·35
Fixed Carbon	50·51
Ash	6·25
	100·00
Calorific value	13·2

The Greta Measures are known to extend at intervals to near the Queensland border.

The Newcastle Coal-field has supplied most of the coal raised in New South Wales during the last 50 years; many of the collieries, however, are now about worked out, and their owners have opened new mines in the neighbouring Maitland field. The Newcastle coal, most of which is obtained from the Borehole Seam (occurring near the base of the series) is of good quality for household and gas-making purposes. Its average composition as calculated from the analyses of 78 representative samples is as follows:—

Hygroscopic moisture	2·01
Volatile Hydrocarbons	36·01
Fixed Carbon	53·27
Ash	8·71
	100·00
Calorific value	12·7

The Illawarra or Southern Coal-field is situated around Bulli as a centre, and is about 150 miles south of Newcastle. The Upper Coal Measures are worked here also, but in the uppermost seam of the series (known as the Bulli seam), and the coal is of a totally different character from that of Newcastle, being essentially a steam coal of good quality. It also makes a splendid hard coke suitable for smelting purposes.

The average composition of the coal from the Southern Coal-field, as calculated from 35 analyses of representative samples, is as follows:—

Hygroscopic Moisture	0·71
Volatile Hydrocarbons	23·65
Fixed Carbon	63·98
Ash	11·66
	100·00
Calorific value	12·68

The Lithgow or Western Coal-field is situated on the Western Railway, 95 miles from Sydney, and here again the coal is obtained from the Upper Coal Measures, but in this instance from the lowest seam of the series. It is essentially a steam coal, but of rather inferior quality to that obtained from the Southern Coal-field.

Its average composition, as calculated from the analyses of 25 carefully taken samples, is as follows:—

Hygroscopic Moisture	2·05
Volatile Hydrocarbons	32·31
Fixed Carbon	53·08
Ash	12·56
	100·00
Calorific value	11·9

The Upper Coal Measures have been proved to be continuous between Newcastle on the north and Illawarra on the south: and also between Sydney on the east and Lithgow on the west. The uppermost coal seam of the series occurs at a depth of nearly 3,000 feet under Sydney, where it is being worked by the Sydney Harbor Collieries Limited.

It is extremely difficult to estimate the total quantity of coal available in New South Wales, owing to the comparatively small amount of prospecting which has been done. Assuming, however, that 10 feet of workable coal underlies the area known to be coal-bearing, and allowing for a loss of one-third of the gross weight in working, it is calculated that there must be 115,346,880,000 tons of available coal in the Permo-Carboniferous Measures within a depth of 4,000 feet.

Kerosene Shale.—A petroliferous mineral which is a variety of Torbanite and is locally known as Kerosene Shale, has been worked with much success in past years at Joadja, near Mittagong, and at Hartley Vale, near Mount Victoria. Both these deposits, however, have been worked out, and the most important deposits now known are those of the Capertee Valley (the property of the Commonwealth Oil Corporation), in the parish of Megalong, near Katoomba, Doughboy Hollow, near Murrurundi, and Marangaroo, near Lithgow.

This mineral occurs as lenticular patches or seams, rarely more than a mile in length or width, on certain horizons of the Upper Coal Measures of Permo-Carboniferous age. The seams vary in thickness from an inch or two up to 4 ft. 6 in., the one in the Capertee Valley being about 4 ft. 3 in. and of fair quality.

Gold.—Although for many years the value of the gold won in New South Wales exceeded that of any other mineral, after the exhaustion of the easily won alluvial deposits there was a considerable drop in the production of the precious metal. It is true that auriferous reefs have been worked in many widely separated localities, and in a number of cases with very successful results. Speaking generally, however, the reefs have not been found payable at considerable depths, and the returns from gold mining have consequently been irregular. In times of general prosperity there is always a falling off in the gold yield, whereas, when other and more payable employment fails, people turn their attention to prospecting for gold, and the yield improves. Amongst the most important gold-fields which have been worked in the State may be mentioned Forbes, Parkes, Young, Kiandra, Gulgong, Grenfell, Wattle Flat, Sofala, Hargraves, Hill End, Lucknow, Temora, Wyalong, Pambula, Hillgrove, etc. Most of these fields are still producing gold, although the mining industry has not been very prosperous at any of them for some years.

The mines of the Cobar field are at present the chief gold producers, and of these the Mount Boppy holds the pride of place. In this mine there is an interbedded auriferous quartz deposit of the type known as a saddle lode (inverted), which occupies the spaces formed by the folding of schistose rocks, which are probably of Pre-Silurian age. The deposit has been worked to a depth of about 800 feet, and mining operations are still being successfully carried on.

A considerable amount of alluvial gold is still being recovered from the beds of rivers by means of dredges, the use of which has been of great assistance to the mining industry during the past decade.

Silver-Lead.—The most important silver-lead field in Australia is situated at Broken Hill, in the north-west of New South Wales. It was discovered in 1883 by Charles Rasp, who marked out a lease under the impression that the ore was tin-stone.

The Broken Hill lode occurs in highly altered rocks, such as schists, gneisses, garnet sandstones, and banded quartzites, which have been intruded by dykes of very coarse pegmatite. These rocks are probably of Lower Cambrian age. They have been much folded, and in a space thus caused an enormous interbedded lode of the type of the Bendigo saddle lodes has been formed. The cap of the lode consisted of manganiferous ironstone, and formed the summit of a low range about 2½ miles long. Under the cap of the lode extremely rich oxidized ores consisting of carbonate of lead and kaolin with chloride of silver and native silver were found. These ores occurred for a width of several hundred feet in places, and beneath them were mixed sulphides of lead and zinc with a high silver content. As greater depth was attained, the proportions of silver, lead, and zinc in the ore declined, and the gangue consisted of rhodonite, making it very hard to crush. Owing, however, to improved methods of treatment, and more particularly the adaptation of the flotation process, the mines have been enabled to profitably exploit the poorer ore, and the mining industry at Broken Hill is in a most flourishing condition to-day. The greatest depth so far reached by any mine at Broken Hill is 1,815 feet, in Block 10.

In addition to silver, lead, and zinc, the Broken Hill ore contains a small proportion of gold and copper. The aggregate value of the metals produced by the principal mines on the lode up to the end of the year 1912 was £70,182,124, and the sum of £16,177,580 was paid to the shareholders.

Another silver-lead field, where the mining industry has been in a flourishing condition during the past twelve years, though on a much smaller scale than at Broken Hill, is known as Yerranderie, and is situated about 80 miles south-west of Sydney. The country rock consists of quartz-felspar-porphyry overlain in places by the Permo-Carboniferous Coal Measures. Lodes of 6 inches to 4 feet in thickness of argentiferous galena occur in the porphyry dipping at an angle of about 28°. Mining operations have been carried on in these lodes under considerable difficulties, there being no railway to the field and the ore having to be carried over mountainous roads to Camden at a cost of £2 to £2 5s. per ton. Nevertheless the returns have been steadily progressive.

Copper.—New South Wales possesses many copper mines, but in a majority of them work has been carried on intermittently, owing to the fluctuations in the price of the metal. When the value of copper falls below a certain figure there are mines which cannot make a profit, and it becomes necessary to close them down; with a rise in price, and the probability of its being maintained for some time, such mines resume operations, and a period of prosperity is entered upon.

Amongst the most important copper fields may be mentioned Cobar, Nymagee, Shuttleton, Mount Hope, Girilambone, Burraga, Cangai, Gulf Creek, Blayney, Cow Flat, and Orange Plains.

The Great Cobar Copper Mine is undoubtedly the most important mine of its class at present worked. It is situated 464 miles west of Sydney, with which it is connected by rail. The lode occurs in slates of probably Pre-Silurian age, and consists of three immense lenses of ore which are the results of replacement of the slates. The ore bodies vary in width from a thread up to 100 feet, and they are at present being worked at a depth of 1,500 feet. Ore only showed at one point on the surface, and there was nothing there to indicate the enormous ore bodies which were afterwards found below. Cobar copper ore contains a variable proportion of gold, and near the surface it was extremely rich, as will be realized when it is stated that in the early years of the mine's history, the copper produced was conveyed by bullock drays for a distance of nearly 300 miles, and paid handsomely notwithstanding. As the workings progressed in depth the ore became poorer in both copper and gold, and at the present time is worth about 2·5 per cent. of the former and nearly 1 dwt. of the latter per ton. The Great Cobar ore, being of a basic character, is treated by partially pyritic smelting in conjunction with silicious ores (containing a little copper and gold) from the Cobar Gold Mine, the Chesney Mine, and the Great Peak Mine, which are all owned by the same company. There are two other lodes (known respectively as the "Middle" and "Eastern") parallel to the one which is being worked. Neither of these has been adequately prospected, and it is quite possible that they may yet be found to contain valuable ore bodies of a similar character to those already exploited.

The Great Cobar Field has already produced about 100,000 tons of copper, 500,000 ozs. of gold, and 1,250,000 ozs. of silver, the aggregate value of which amounts to about £8,000,000.

Tin.—Tin ore was first discovered in commercial quantities at Elmore, near Inverell, and shortly afterwards at Emmaville in the year 1872. Large quantities of stream tin were subsequently recovered from both districts, at first by means of ordinary sluicing appliances, and more recently by pump dredges, which are still employed. Most of the stream tin has been derived from stanniferous greisen, in which the cassiterite occurs as scattered grains, which become concentrated by the action of running water as the greisen is decomposed. Stanniferous lodes also occur, but are not often met with. The most important tin-bearing lodes are the Ottery lodes at Tent Hill (not being worked at present), and Butler's Lode, 8 miles north of Emmaville.

Tin-bearing pipes are also a feature of the Emmaville District. They occur in granite and are oval or cylindrical in form, and generally a few feet in diameter. Their downward course is irregular and limited to 30 or 40 feet. The tinstone is disseminated through a gangue of felspar quartz and chlorite, and is frequently present in the proportion of 50 per cent.

Alluvial tin ore also occurs in granite country at Dora Dora, 40 miles east of Albury, and lodes of tinstone and wolfram traverse granitic rocks at Jingellic, 20 miles further east. At Tabletop, near Wagga, tinstone and wolfram are found both in lodes and alluvial deposits.

At Euriowie, north of Broken Hill, tinstone occurs in coarse crystals scattered through pegmatite dykes. Attempts have been made to work these deposits, but the cost of freight from such an outlying district is almost prohibitive.

The most recent discovery of tin ore in New South Wales was at Ardlethan, a town on the railway, about 40 miles west of Temora. The ore is found in lenticular chutes in granite close to its junction with Silurian slates. In one instance blocks of ore, weighing as much as a ton, and containing 50 per cent. of tin, were found lying on the surface. Considerable activity has been displayed on this field since its discovery, and if the deposits are found to maintain their values to a depth, it should have a prosperous future.

Iron.—Deposits of iron-ore are found in various localities in New South Wales, the most important being situated at Coombing Park near the town of Carcoar, and at Cadia, about 14 miles west of Orange. The first-named deposit has been estimated to contain 2,571,000 tons. It has been quarried to a considerable extent by the Messrs. Hoskins Brothers, who have established iron smelting works at Lithgow. The ore consists of an intimate mixture of limonite and hematite in varying proportions, and the analysis of a bulk sample yielded 55·8 per cent. of metallic iron, 7·45 per cent. of silica, and ·396 phosphoric anhydride. The Cadia deposit consists of beds of hematite and magnetite which have been estimated to contain about 39,000,000 tons, much of which is said to be suitable for the production of steel by the Bessemer process.

Iron smelting works are also in course of erection at Newcastle. They are the property of the Broken Hill Proprietary Silver Mining Company, and it is proposed to bring the ore from their Iron Knob Mine in South Australia.

Aluminium.—Bauxite, the mineral from which aluminium is made, and which consists principally of alumina, is found in several districts in the State, as at Parish of Wingello, County of Camden, and also near Emmaville and Inverell, where it occurs both in the pisolitic and massive forms. These deposits are not being utilized at present for the manufacture of aluminium, but there is no doubt that attention will be attracted to them in the future.

Antimony.—The principal mining field where stibnite, or sulphide of antimony, is found in quantity, is Hillgrove, 20 miles east of Armidale, where it is associated with gold and scheelite. Antimony mining, however, is a spasmodic industry, owing to the fluctuations in the price of the metal. There is not much demand for antimony at present, and consequently the mines are not being worked.

Bismuth and Molybdenum.—Ores of bismuth associated with molybdenite are found at Kingsgate, 18 miles east of Glen Innes. The deposits consist of pipes similar in form to those in which tin occurs near Emmaville. The Kingsgate pipes intersect granite rocks near their junction with slate. They are roughly circular or oval in section, and descend irregularly, dipping at an average angle of 30° towards the junction of the two formations. Individual pipes have been worked for a distance of 460 feet on the underlie. The gangue is quartz, and this is impregnated with molybdenite, native bismuth, sulphide, carbonate, and oxide of bismuth.

Similar deposits occur at Pheasant Creek, 30 miles north-east, and also at Whipstick, 14 miles from Pambula on the South Coast. In the last-named occurrence the gangue consists of quartz and felspar with a little mica and garnet.

Tungsten.—Scheelite and wolfram occur in many localities in the State; the former is worked pretty extensively at Hillgrove, where it occurs, associated with stibnite, in auriferous quartz reefs in intrusive granite near its junction with slate.

Although wolfram is widely distributed in New South Wales, its occurrence in commercial quantities is rare. The wolfram mining industry is, however, in a prosperous condition at Torrington, to the north of Emmaville, where it occurs in association with bismuth.

The sedimentary rocks of the neighbourhood are believed to be the lower marine (Gympie) beds of the Permo-Carboniferous system. They have been intruded by granite, and subsequently both granite and slate have been intruded by a rock which now consists largely of secondary silica and contains also topaz, wolfram, and bismuth. This rock is believed to be an altered granite, and the name topaz-greisen has been proposed for it.

The wolfram occurs in crystals scattered through the greisen; also more plentifully in quartz veins penetrating that rock, and again in pegmatite dykes associated with it.

Diamonds are won from alluvial drifts at Copeton, 17 miles from Inverell. A Dutch Company has recently been formed to extract diamonds from the dolerite matrix in which they have been proved to occur at Oakey and Staggy Creeks in the same district.

Opal.—Precious opal occurs in veins or seams in a soft white siliceous rock in the Desert Sandstone Series, of Upper Cretaceous age. It is extensively worked at two widely separated localities, viz., at White Cliffs,

north of Wilcannia, and at Lightning Ridge, north of Walgett. In the last-named place the rare variety known as black opal, of great beauty and value, is obtained.

Alunite or Alumstone.—This mineral occurs in considerable quantity at Bullah Delah, where a mountain 900 feet high is largely composed of it. The alunite appears to have been formed from the decomposition of rhyolites, which form the base of the mountain. The mineral is partially treated on the ground, and then exported to Scotland for the manufacture of alum.

TABLE SHOWING THE QUANTITY AND VALUE OF THE MINERALS WON DURING THE YEAR 1912, AND TO THE END OF 1912.

New South Wales.

Mineral.	Production for Year Ending 31st December, 1912		Total Production to 31st December 1912.	
	Quantity.	Value.	Quantity.	Value.
		£		£
Coal . ..	9,885,815 tons	3,660,015	181,595,980 tons	69,087,688
Gold . ..	165,295 oz. fine	702,129	13,998,775 oz. fine	59,462,975
Silver	2,389,195 oz.	251,652	26,194,502 oz.	3,328,713
Copper	11,034 tons	579,791	216,073 tons	11,784,102
Tin	2,075 ,,	338,074	105,144 ,,	9,327,609
Lead	17,251 ,,	264,530	138,191 ,,	2,000,911
Antimony	62 ,,	355	16,653 ,,	305,225
Opal . .	..	35,008	..	1,330,207
Wolfram	172 tons	16,584	1,357 tons	132,517
Manganese	..	..	577 ,,	1,662
Bismuth	6 tons	1,210	541 ,,	128,537
Molybdenite	57 ,,	3,706	304 ,,	36,036
Limestone	33,186 ,,	11,066	1,124,671 ,,	702,814
Ironstone	1,093 ,,	761	106,917 ,,	81,618
Scheelite	56 ,,	4,963	1,130 ,,	100,848
Iron	32,677 ,,	130,708	337,445 ,,	2,113,786
Iron Oxide	3,757 ,,	4,763	23,696 ,,	30,748
Lime	35,657 ,,	44,478	307,553 ,,	277,927
Portland Cement ..	..	368,280	..	1,839,684
Shale (oil)	86,018 tons	34,770	1,651,434 tons	2,322,831
Diamonds . ..	2,239 cts.	2,001	178,970 cts.	120,408
Alunite	3,425 tons	13,700	39,035 tons	119,543
Chrome .. .	23 ,,	60	30,835 ,,	101,468
Marble	..	1,340	..	23,064
Platinum	610 ozs.	3,880	12,990 ozs.	29,010
*Stone (building, etc.) .	..	559	..	24,176
*Slates .. .	..	..	79,234	890
Cobalt	..	.	885 tons	8,065
Coke . ..	241,159 tons	162,454	3,012,083 ,,	2,138,667
Quicksilver .. .	..	..	1,010 lbs.	126
*Grindstones	..	176	..	2,842
Zinc (metal and concentrates)	520,518 tons	1,766,242	2,819,718 tons	7,539,913
Silver, Lead Ore Concentrates, etc.	345,307 ,,	3,229,614	7,442,007 ,,	54,892,276
Sundry Minerals ..	..	8,566	..	122,084
Totals	..	11,641,435	..	229,518,970

* Quantity and value exported.

2. Victoria.

Although gold was first discovered in New South Wales, it was in Victoria (which was proclaimed a separate Colony about this time, viz., 1st July, 1851) that the richest and most extensive gold-fields occurred. Most of these fields were found immediately after a reward of 200 guineas had been offered for the discovery of a gold-field within 200 miles of Melbourne.

The alluvial gold deposits of Anderson's Creek were discovered on 5th July, 1851, those of Buninyong on 8th August, Ballarat on 8th September, and Bendigo on 10th December. Many other alluvial fields were found within a few months, and the immediate result was a large influx of people all eager to prospect for gold. In the following year, 1852, there were 40,000 men at Ballarat, a like number at Bendigo, and 25,000 at Castlemaine, in addition to the many thousands who were scattered over the smaller fields. The output of gold in Victoria for the year 1852 was 2,218,782 ozs., valued at £8,875,128, while in 1856 it rose to its maximum, viz., 2,985,991 ozs., valued at £11,943,964. For many years afterwards the value of the gold yield exceeded five millions sterling, and the foundations of Victoria's present prosperity, as well as the formation of her principal townships, was thus the direct result of the discovery of the gold-fields.

Auriferous Lodes.—The auriferous quartz mining areas of Victoria have been classified as follows:—(1) the Western or Lower Ordovician group, including Ballarat, Bendigo, Castlemaine, Stawell, Ararat, and Maryborough districts; (2) the Central or Silurian group, including the Walhalla, Wood's Point, and Upper Yarra fields; and (3) the Eastern group, including the Upper Ordovician and the extensive metamorphic series of Bethanga, Mount Wills, and Cassilis districts.

Ballarat.—The auriferous lodes of Ballarat occur in an area of acutely but irregularly folded slates and sandstones which are believed to be of Ordovician age. The axes of the folds have a meridional strike, and the anticlines and synclines follow an easterly and westerly dip.

In Ballarat East a zone of these slates and sandstones about 350 feet in width has been proved favorable to the occurrence of gold, but it is only when these beds have an easterly dip that the intersecting reefs are profitable. These beds are traversed and faulted by north and south felsite dykes. The faults are known locally as "leather jackets," because they usually contain a layer of leathery "pug" or "casing," which can be removed in sheets. The "leather jackets" form the foot-walls of extensive quartz formations (often up to 40 feet in width) from which spurs frequently extend westwards, and these deposits have produced great quantities of gold.

A second series of dykes (limburgites) intruded the Ballarat gold-field in an east and west direction at a date subsequent to the formation of the quartz reefs, and probably had some influence upon their enrichment.

A very interesting feature of Ballarat East is the occurrence of what are termed "indicators," which have been found to have a distinct relation to certain deposits of gold. The indicators are thin beds of slate (and sometimes sandstone) which usually contain pyrites, and occasionally a little quartz.

They occur in the 350 feet of favorable beds previously referred to, and are therefore usually intersected and faulted by the "leather jackets." The most persistent and important of these occurrences is known as "The Indicator": it consists of a slate bed one-eighth of an inch thick with a pyritous seam running through it. There is no gold in the Indicator itself, but wherever it is intersected by quartz veins the latter are found to contain deposits of gold, frequently in the form of slugs or masses weighing hundreds of ounces.

Other analogous beds are known as "the Western Indicator," "the 4-ft. slate," "the 12-ft. slate," and "the big sandstone." Much more gold, however, has been obtained form the large quartz formations of Ballarat East than from the slugs found at the intersection of quartz veins with the indicators.

The greater part of Ballarat West is covered by a thickness of about 400 feet of basalt, of which there are four distinct flows. together with alluvial clays and gravels. Beneath this covering are the folded slates and sandstones. and these include a favorable series of beds 80 feet wide, containing four black graphitic slate beds, which appear to have had a marked effect upon the deposition of the gold. Payable lodes have only been found within the 80-ft. zone, and again only where these beds have a westerly dip. The three principal lodes are the Consols, or most easterly, the Guiding Star, and the Albion, or most westerly. Other important lodes are the Phœnix, an inverted saddle, and the Prince of Wales, which is situated on the southern end of the field. The Consols lode has been as much as 70 feet wide on the anticline, and 50 feet in the syncline, and it averaged 4 feet in width down to a depth of 1,000 feet in the celebrated Band and Albion mine. Following a southerly pitch this lode was worked to a depth of nearly 3,000 feet in adjoining mines. The Guiding Star lode was payable for 5,000 feet in length, and the Albion line of lode has been traced for 4 miles. The black slate horizon on the Albion anticline has been denuded for a distance of several thousand feet, shedding the rich alluvial gold deposits for which this portion of the field was famous. Below the favorable black slate zone there appears to be a thickness of about 1,000 feet of barren rocks, while above it there are indications of other favorable strata.

The two most profitable quartz mines at Ballarat West were the Band and Albion Consols, which paid £252,001 in dividends, and the Star of the East, which paid £281,400.

Bendigo is at present the most prosperous gold-field in Victoria, and is also the one where mining operations have been carried to the greatest depth. The field has a length of about 15 miles by a width of 3, and it may be regarded as the type-district of the lodes known as saddle-reefs. The prevailing rocks are slates and sandstones of Lower Ordovician age, but at Harcourt, about 15 miles to the south, an intrusive *massif* of granite has altered the sediments for a distance of 25 chains from the junction. The sedimentary series has been thrown into a remarkably regular succession of anticlinal and synclinal folds. whose axes have a strike of about N. 16° W.; moreover, the beds undulate in this direction as well as in that at right angles to it, though not to the same extent. A section across the field from east to west would therefore show the slates and sandstones bent into a regular series of corrugations,

while a north and south section would show a similar formation in a less pronounced degree. Owing to the bending or folding of the strata, lune-shaped cavities or spaces have been formed between contiguous beds, the spaces being widest at the tops of the anticlines and at the bases of the synclines, and thinning out gradually between the two. In these spaces auriferous quartz has subsequently been deposited, and the lodes thus formed have received the name of saddle-reefs, owing to their resemblance to a saddle in cross-section. The thickest part of the reef is called the cap of the saddle, while the eastern and western extensions are termed the legs. In the case of a perfectly formed saddle-reef occupying the dome of an anticline it will be understood that the deposit will have a quaquaversal dip, and will gradually taper out to nothing in a downward direction. The anticlinal axes are locally known as "centre-country," and fifteen of these nearly parallel axes have been proved to carry saddle-reefs the distance from one to the next ranging from 300 to 1,300 feet. The angle of dip of the beds varies considerably, but the average is about 65°. The caps of the reefs are often from 20 to 30 feet in width, and even more in thickness or height, but the legs are seldom more than 3 or 4 feet wide, and they rarely extend downwards for a greater depth than 100 feet. Saddle-reefs recur in depth, and as many as 24 of them have been met with in a depth of 2,200 feet in the Lazarus mine. The sedimentary rocks have been intruded by a series of small monchiquite dykes, locally known as "lava streaks," which have also intersected and in many instances faulted the reefs.

Besides the saddle-reefs, "spurs" are a feature of the Bendigo field, and have yielded large quantities of gold.

There are no less than 53 shafts over 2,000 feet deep on the field, and several exceed 4,000 feet in depth, the deepest being the Victoria Quartz shaft, which is down 4,614 feet.

Amongst the most successful mines at Bendigo are the Garden Gully United, which has paid £852,169 in dividends, and the South New Moon, which has distributed profits amounting to £492,000. The output from Bendigo for the year 1912 was 168,177 ozs. of gold.

Castlemaine gold-field resembles Bendigo in that the lodes are chiefly saddle lodes, and there are also fault lodes occurring in Lower Ordovician rocks, which have been folded into anticlines and synclines. Fault or "blocky" lodes consist of laminated quartz up to several feet in thickness, with large masses of spurs and veins traceable for hundreds of feet, the spurs forming at times payable stockworks.

Maryborough gold-field occurs in folded Ordovician slates and sandstones, which have been traversed in every direction by dykes of porphyry, porphyrite, and lamprophyre. The principal ore deposits are quartz lenses occurring on either wall of lamprophyre dykes, and large lode channels with main veins and stockwork spurs adjacent to such dykes.

Daylesford is an important gold-field, the conditions under which the gold occurs being very similar to those at Ballarat. The Ordovician slates and sandstones have been folded into anticlines and synclines, which are traversed by dykes and cut by faults. The Ajax group of lodes, which are the most

important, have formed in west-dipping faults, which intersect certain favorable east-dipping beds, while "flat makes" between the faults have also proved rich gold producers.

The Cornish group of lodes to the east of the Ajax line are also west-dipping fault lodes in a series of favorable east-dipping strata.

In the *Maldon* gold-field there are lodes of the fault type similar to those of Ballarat, saddle-reefs like those of Bendigo, and quartz lodes directly associated with dykes analogous to those of Maryborough. The prevailing rocks are folded slates and sandstones of Ordovician age, which have been altered by contact with intrusive granite. The most important mines are the Beehive, the Union, and the South German; the latter is still giving good returns.

Stawell and *Lauriston* are other examples of gold-fields characterised by the occurrence of saddle-reefs. At *Berringa* also saddle-reefs have been successfully worked, as well as fault lodes similar to those of Ballarat.

St. Arnaud is another gold-field where deep quartz mining has been highly profitable. The Lord Nelson group of lodes is the most important; they have a westerly dip and intersect Lower Ordovician strata having a nearly similar inclination. Up to December, 1912, the Lord Nelson mine paid £265,350 in dividends.

Walhalla gold-field is situated in an area of highly folded and contorted slates and sandstones of Silurian age. Cohen's reef has been most successfully worked in two mines known as the Long Tunnel, and Long Tunnel Extended. It is a true fissure lode, and is associated with a dyke of quartz-mica-diorite, which is sometimes on one side of it and sometimes on the other. The strike of the lode is N. 18° W., and it dips W. 18° S. at a high angle. It has been worked down to a depth of 3,375 feet, and has yielded 1,175,625 ozs. of gold, and paid £2,378,290 in dividends. In width the lode varied from a thread up to 12 feet, and exceptionally up to 50 feet.

Wood's Point gold-field is also within an area of folded Silurian slates and sandstones. The principal feature of the field is the occurrence of gold-bearing "flat reefs" or "floors" intersecting diorite dykes. These flat reefs vary in thickness up to 10 or 20 feet; and in one mine, The Morning Star, thirteen distinct flat reefs have been worked to a depth of 400 feet (water level) for a yield of over £1,000,000. Other important mines of a similar character are the New Loch Fyne and the A1. The former has paid nearly £110,000 in dividends.

At *Bethanga*, on the Upper Murray, and *Cassilis*, in East Gippsland, lodes containing auriferous sulphide ores occur. Those of the first-named field are highly arsenical and have proved very refractory; the Cassilis ores are being successfully treated.

Alluvial Leads.—The denudation of the auriferous reefs has produced extensive alluvial deposits on all the gold-fields, and it was the shallower of these which were worked with such successful results in the early days of gold-mining. Subsequently the gold was traced into the deep leads, which are river beds of Tertiary age, now covered by accumulations of clays and sands, and frequently by lava flows. In Victoria these ancient

auriferous valleys measure in the aggregate several hundred miles in length, and they trend in a northerly and southerly direction from an old divide closely approximating in position to the existing Main Dividing Range The value of the gold won from the deep alluvial leads and their shallower tributaries is probably not less than £150,000,000. In the earlier and more prosperous years of gold mining the principal alluvial fields were Ballarat. Bendigo, Creswick, Castlemaine, Maryborough, Ararat, Stawell, Chiltern, Rutherglen, and Beechworth. In most of these centres the gold yields were phenomenal, and many large nuggets were found. At the present time deep leads are being worked at Ararat Beaufort (Fiery Creek), Poseidon, Chiltern, and Rutherglen, and new leads are still being systematically searched for by means of the drill

Of recent years alluvial deposits that would be unpayable by ordinary mining methods have been worked successfully in many localities by means of dredges, and at the present time there are 26 of these at work in the immediate vicinity of Bright.

Nuggets.—The occurrence of very large gold nuggets in positions close to the surface in alluvial ground, where, by reason of their great weight, it seems unlikely that they could have been transported by running water, has given rise to much speculation as to their origin, and some years ago it was suggested that they may have been formed *in situ*, either wholly or in part, by the deposition of gold from aqueous solutions. The largest nugget ever found ("The Welcome Stranger," from the Black Lead, Moliagul) weighed 2,520 ozs. in its natural state, and contained 68 lbs. of quartz. It was covered by only a few inches of surface soil.

The discovery of several large nuggets one of which weighed 953 ozs., a few inches below the surface, at Poseidon, in December, 1906, and the subsequent unearthing of a number of others at intervals, in the same lead has enabled more careful observations to be made of the conditions under which they occur, and there now appears to be little doubt as to their source.

Every nugget of gold found in the Poseidon lead was observed to lie in the immediate vicinity of an "indicator," which could be seen traversing the bed rock forming the floor of the lead. The indicators consist of thin beds of slate, which have been more or less replaced by laminated quartz, and which contain pyrites veins. Occasionally the pyrites has been oxidized and the indicator then consists of ferruginous laminated quartz of a saccharoidal structure. Samples of the indicators have been assayed and found to contain no gold. The occurrence of similar indicators in the Ordovician rocks of Ballarat East, and the fact that where they are intersected by quartz veins the latter are frequently found to contain massive slugs of gold strongly suggests a similar origin for the nuggets obtained in the Poseidon alluvial lead. Most of these nuggets have a considerable quantity of vitreous quartz attached to them, and it is believed that, in the process of denudation they have been shed from quartz reefs at the intersection of the latter with the indicator. It is probable therefore that if the indicators were followed into the solid rock, other cross veins would be met with, and that undisturbed masses of gold would be found at the intersections, as is the case in Ballarat East.

Bituminous Coal.—There are three isolated areas of Jurassic Coal Measures in Victoria, two of which, viz., the Wannon River Watershed, and the Otway-Bellarine district, have not been proved to contain workable seams of coal. In South Gippsland the measures occupy an area of 2,100 square miles, and a belt about 50 miles long by 10 miles wide, extending from Kilcunda to Morwell, has been proved to contain some payable seams. Mining is now being carried on at Kilcunda, Wonthaggi, Outtrim, Jumbunna, and Korumburra, but the coal seams, with the exception of those at Wonthaggi, rarely exceed 3 feet in thickness.

At the Wonthaggi State Coal Mines the seam reaches a thickness of 7 ft. 8 in., with two shale bands varying from a quarter of an inch to 1 inch in thickness. The seam has been much faulted, and this adds considerably to the cost of winning. The coal is of good quality, but is friable, and therefore produces a considerable proportion of "smalls." The average composition of the coal is as follows :—

Hygroscopic Moisture	4·93
Volatile Hydrocarbons	34·32
Fixed Carbon	51·43
Ash	9·32
	100·00
Calorific value	11·97

The total annual output of coal is at present about 600,000 tons, of which the State Mine produces 456,000 tons.

Brown Coal.—There are three main deposits of Brown Coal of Tertiary age in Victoria, viz. :—

1. Morwell area, of about 800 square miles.
2. Alberton area, of about 200 square miles.
3. Altona Bay area, extending from Melbourne to Werribee, containing 700 square miles.

The deposits are the thickest in the world; one bore at Morwell passed through 780 feet of brown coal in a depth of 1,010 feet; the three largest beds being 266, 227, and 166 feet thick respectively. The composition of the Morwell coal is as follows :—

Water	35·08
Volatile Matter . ..	29·24
Fixed Carbon	33·28
Ash	2·40
	100·00
Calorific value	8·53

There is every reason to believe that practical use will be made of this fuel in the future.

Tin.—Tertiary leads containing stream tin have been worked at Beechworth, Eldorado, the Upper Murray, Toora, and the Latrobe Valley, but the workings have not been very extensive. At Toora, in South Gippsland, the deposit of gravels and clays, containing a little tin and gold, is about 150 feet in thickness and extends for about a mile and a half in length. It occupies an old river valley in the Jurassic rocks and has evidently been carried a long distance. A very complete hydraulic plant, which cost £20,000, has recently been erected and is now treating the gravels; the question as to their commercial value will therefore soon be settled.

In the North-Eastern district, around Tallandoon and Eskdale, lodes, pegmatite dykes and greisens carrying tin-ore occur, but there has been very little mining there.

Copper.—At the Thomson River, near Walhalla, the Silurian rocks have been intruded by a hornblendic dyke 60 feet wide, and through a width of 20 feet of this rock copper sulphides, containing platinum and palladium are disseminated. The chute of ore has been proved for a length of about 70 feet. Although essentially a concentrating ore, it has hitherto been smelted as it came from the mine and 1,290 tons yielded 3 per cent. of copper and 18 grains of platinum per unit of Cu.

To the west of the ore-body an enriched vein of sulphides is said to have yielded from 10 to 13 per cent. of copper for a length of 120 feet by a depth of 40.

Antimony.—Sulphide and oxide of antimony occur in quartz veins in dykes in the Silurian rocks and occasionally in the Ordovician. At Costerfield a considerable quantity of antimony has been won, and at present about 55 tons of sulphide concentrates containing $2\frac{1}{4}$ ozs. of gold per ton are being exported weekly.

Bismuth occurs in small quantities at Redbank, Lintons, Wombat Creek, and Maldon.

Molybdenite is also found in small quantities the best deposit being at Wangarabell, in East Gippsland.

Wolfram and *Scheelite* occur in lodes in Ordovician strata at Linton and Chiltern, and in granite at Mount Murphy. The deposits, however, appear to be of small extent.

Gypsum has been extensively worked in Tertiary deposits at Boort and Lake Boga. At Kow Plains, in the Mallee District, deposits of earthy gypsum occur over an area of about 100 square miles. The mineral contains about 94 per cent. of calcic sulphate, ($CaSO_4 + 2OH_2$). It occupies ridges about 20 feet high and also extends to a depth of about 3 feet below the intervening plains. These deposits are probably the most extensive in Australia.

Diatomaceous Earth is found in deposits of Tertiary age in many localities, the most notable being Lillicur, near Talbot, where extensive deposits are now being worked.

TABLE SHOWING THE QUANTITY AND VALUE OF MINERALS WON DURING THE YEAR 1912 AND TO THE END OF 1912.

Victoria.

Name of Metal or Mineral.	Production for Year ending 31st December, 1912.		Total Production to 31st December, 1912.	
	Quantity raised.	Value.	Quantity.	Value.
	fine ozs.	£	fine ozs.	£
Gold	480,131	2,039,464	68,672,868	291,703,453
Silver	17,424*	2,200	1,360,252*	206,359
	..	..	30,058	7,816
Platinum	..	..	184	989
	tons.		tons.	
Coal	589,143	258,455	4,667,054	2,436,017
Brown Coal	4,012	866	73,185	26,374
Copper and Copper Ore	..	..	18,694	215,761
Tin Ore	48	5,733	15,715	782,680
Antimony Ore	2,430	16,162	37,896	240,874
Silver-lead Ore	..	..	793	5,760
Iron Ore	..	..	5,434	12,540
Wolfram	10	574	65	5,[illegible]59
Diamonds	..	20	.	128
Sapphires, etc.	..	..	..	630
Gypsum	2,078	3,359	21,198	14,473
Magnesite	211	633	383	1,143
Kaolin	288	342	5,535	11,366
Diatomaceous Earth	850	3,400	4,743	19,352
Manganese Ore	20	60	45	212
Building Stones (Basalt, Sandstone, Granite, Slate, Flagstone, Limestone (for making lime), also Crude Salt)	..	..	..	3,996,423†
Pigment Clays	13	26	81	106
Totals	..	2,331,294	..	299,688,115

* Extracted from gold at Melbourne Mint.
† These returns are from 1866 only, and are collected by the Government Statist. The value of building stones (including crude salt) raised during 1911 was £151,713—total to end of 1911 only, the figures for 1912 not being yet available.

3. Queensland.

The potential wealth of Queensland is remarkable, by reason of the extent and diversity of the mineral deposits already discovered; the mining industry is in a healthy condition to-day, and vast areas of the State still remain practically unprospected.

The Coal-fields of Queensland are of great extent, and are of three ages, viz., Permo-Carboniferous, Trias-Jura, and Cretaceous. The first-named will probably prove to be the most important in the future, as the coal they contain is of the best quality, and the seams are of greater thickness and uniformity than those of the fields of more recent age; hitherto, however, they have been the least developed. They extend for a length of about 350 miles in a northerly direction from near the Southern railway across the Central line to within 60 miles of Bowen, and other isolated areas occur at Blair Athol, near Clermont, and at Mount Mulligan, about 50 miles west of

Cairns. The Blair Athol field is a very remarkable one, for though only $2\frac{1}{2}$ miles long by $1\frac{1}{2}$ wide, as at present known, it contains, at a depth of about 120 feet from the surface, a seam of good hard steam coal, 66 feet thick, and without bands.

It has been estimated by Mr. Dunstan, Government Geologist, that the Permo-Carboniferous seams probably contain 1,000,000,000 tons of coal.

The Trias-Jura coal-fields are of special interest because the greater proportion of the coal hitherto produced in Queensland has been obtained from them, particularly from the neighbourhood of Ipswich, where coal-mining has been carried on for over 50 years. The area of the productive Trias-Jura Coal Measures is approximately 70 square miles, chiefly in the south-eastern quadrant of Queensland, and it has been estimated that they probably contain 470,000,000 tons of coal.

The Cretaceous Coal Measures cover a wide area in the centre of Queensland, where they contain supplies of artesian water, and where their coal seams have not yet been proved productive. An easterly development, however, of these measures occurs at Burrum, near Maryborough, where collieries have been working for 30 years. The productive area of the Burrum coal-field is about 6 square miles, and it has been estimated to contain approximately 104,000,000 tons of coal.

In the aggregate, the Queensland coal-fields which are known to be productive probably contain about 1,574,000,000 tons of coal, in seams over 1 foot in thickness.

Gold is very widely distributed throughout Queensland, and many isolated gold-fields have been worked since the precious metal was first discovered in 1852.

Gympie Gold-field is situated about 100 miles north of Brisbane. Alluvial gold was first discovered here in 1867, and the first auriferous reef was found in the same year. The total yield of gold from this field up to the end of the year 1912 was £11,270,166.

The rocks in which the auriferous reefs occur have been named by the Queensland Geological Survey the "Middle Gympie Series," and are of Permo-Carboniferous age, as determined by numerous marine fossils found in them. These beds consist of limestones, shales or slates, conglomerates, tuffs, and interbedded diabases and greenstones. At least seven distinct beds of black graphitic or anthracitic slate occur in these rocks, and have a very marked influence on the gold contents of the reefs intersecting them. In thickness these graphitic beds vary from a mere thread up to 200 feet. The beds have a general dip to the east at an angle of about 25 degrees, while the inclination of the reefs is generally to the westward at an angle of about 60 degrees. A distinctive feature of the field is that payable gold values are only found when the reefs have a westerly dip, and where they intersect black or graphitic slates, dipping in the opposite direction. Occasionally a bed of graphitic slate is found to merge into grey or purple manganiferous slate, and where this happens the intersecting reefs are almost invariably found to be barren. Furthermore, where a reef is affected by a normal fault within the limits of a bed of graphitic slate an enrichment of the reef is produced, but in the case of a reversed fault the reef is found to be barren.

The reefs vary in thickness from a thread to 20 feet. Some exceptionally rich yields of gold have been obtained, and in one instance one of the monthly dividends of a mining company amounted to £68,000, a sum equivalent to its nominal capital. At the present time the field is in a somewhat depressed condition, and its future prosperity appears to depend upon the success of attempts now in progress to test the third or lowest graphitic slate bed recently found to extend to the east at considerable depths below the Monkland slates.

Charters Towers is a small but very rich gold-field situated on the Northern railway line 82 miles south-west of Townsville. The oldest rocks on the field are schists, slates, and quartzites, which have been intruded and metamorphosed by granite. Later dykes of felsite and diorite have intersected the granite and sedimentary rocks. The gold, associated with galena, pyrites, and some blende, occurs in quartz reefs, which are found chiefly in the granite, and almost invariably in proximity to igneous dykes. The principal lines of reef are the Day Dawn, Brilliant, St. George, and Queen's, which all have an east and west strike with a northerly dip. They vary considerably in width, occasionally widening to as much as 50 feet. Over £27,000,000 worth of gold has been won at Charters Towers since 1872, and although the field has not been in a very flourishing state for some time, the geological features connected with the occurrence of the gold point to the probability of a renewed prosperity.

Mount Morgan, 25 miles south-west of Rockhampton, was discovered in 1882. It is unquestionably the most remarkable gold and copper mine in Australia. An area of 1 square mile was purchased from a selector for £640, and a company, with a capital of £1,000,000, was subsequently formed to work it for gold. The upper portion of the deposit, consisting principally of limonite, was enormously rich in fine gold. Though the metal was seldom visible in the ironstone, much of the latter contained from 30 to 40 ozs. of gold per ton, and in one year the Company paid a million sterling in dividends. The total amount hitherto paid to the shareholders is nearly nine millions.

The geological foundation upon which this extraordinary deposit was formed consisted of a series of limestones, and banded claystones and tuffs, with sills and dykes of quartz porphyry. Subsequently this stratified series, which is probably of Carboniferous age, was intruded by hornblendic granite, and still later by andesitic dolerite dykes of at least two ages. It is probable that the intrusion of the hornblendic granite was the cause of (1) the metamorphism of the sedimentary series; and (2) the impregnation of these rocks with iron pyrites containing small proportions of gold and copper. The later intrusions of the dolerite dykes, of which there is a complete network, probably completed the alteration (silicification) of the ore bodies, which in the lowest levels, consist of massive quartzite impregnated with low-grade copper and gold bearing pyrites. The invasion of the dolerites was probably also responsible for vigorous solfataric action, which had the effect of concentrating on the top of the deposit pyrites containing high proportions of gold and copper. Subsequently atmospheric agencies caused the decomposition of the pyrites, the bulk of the gold being left in extremely rich limonite ore, while the copper was leached and redeposited between the 300 and 650 ft. levels. Below the latter depth the ore becomes gradually poorer.

The gold in the limonite was extremely pure, being worth £4 4s. 8d. per ounce.

The Mount Morgan ore body is approximately wedge-shaped, its dimensions being about 1,200 feet in length by 500 in width, and it is believed to thin out at a depth of about 1,100 feet.

An extremely good fire-brick is made from a bed of shale, 30 feet thick, found in the Trias-Jura rocks in the vicinity of Mount Morgan.

Amongst other gold-fields which have been worked with greater or less success are Clermont, Croydon, Coen, Etheridge, Eidsvold, Calliope, Hamilton, Palmer, Ravenswood, and Starke.

Copper.—Undoubtedly the most important copper producing territory in Australia is the Cloncurry Field, which consists of an area of primary rocks (probably Silurian) about 200 miles in length by 100 in width. Cloncurry is situated 480 miles west of Townsville, with which it is connected by rail, and about 220 miles south of the Gulf of Carpentaria.

The prevailing rocks are schists, quartzites, indurated slates, marmorized limestones and calcareous tuffs, with intrusive granites, porphyries, diorites, etc.

A notable feature of the district is the occurrence, along the tops of ridges, of lenticular masses of hematite.

Although comparatively little prospecting has yet been done, quite a number of deposits of extremely rich copper ore has been opened, and some of these have been developed into very important mines. Generally speaking the ore deposits occur as interstratified lenses and bunches, sometimes of very large dimensions, and a small proportion of gold is frequently associated with the copper. The field has unquestionably a great future before it as a copper-producing area. Amongst the most important mines of the Cloncurry Field are Mount Oxide, Mount Cuthbert, Mount Elliott, The Hampden, The Duchess, and the Great Australia.

The Great Fitzroy is an important copper mine situated 10 miles north of Rockhampton: other notable deposits occur at Mount Perry, and at Peak Downs, near Clermont.

Tin mining was commenced at Stanthorpe, near the southern border of Queensland, in 1872, and for a period of about eleven years afterwards large quantities of tin-stone were recovered from the granite of that district. Thereafter the production gradually decreased, though tin mining is still carried on—principally by means of dredges.

The Herberton District, in Northern Queensland, is the principal tin-producing field of the State at the present time other important tin-bearing localities being Annan, Kangaroo Hills, Fossilbrook, and Stanhills, near Croydon.

The *Herberton* and *Chillagoe* Districts constitute an important mineral field, and contain deposits of tin, copper, silver-lead, wolfram, bismuth, molybdenite, antimony, gold, monazite, and coal. The country is very mountainous its altitude varying from 1,000 to 4,000 feet above sea-level. It is situated to the west of Cairns, with which it is connected by railway

The oldest rocks about Herberton are tuffaceous sandstones and shales, probably of Carboniferous age, which have been intruded and highly metamorphosed by granites and quartz-porphyries, while both the latter and the sedimentary series have been intruded by later dykes of diorite, andesite, and elvan. The alteration of the sandstones and shales near Herberton and Irvinebank has been so complete that little or no trace of their original bedding can be distinguished, though at Stannary Hills fine contorted sections can be seen in the banks of Eureka Creek.

The ore deposits occur both in the sedimentary and in the intrusive rocks, but generally within a short distance of the boundary between the two. True fissure lodes are of comparatively rare occurrence in this field, the ore bodies consisting for the most part of pipes, bunches (chutes) or impregnations.

Near the town of Herberton large quantities of stream tin were obtained over 30 years ago from an alluvial lead which was traced down under basalt and which is still being worked. Subsequently quite a number of ore deposits was found in the quartz-porphyry near the alluvial lead, and these developed into most irregularly shaped chutes or bunches, some of which were extremely rich. They are of all sizes, but rarely exceed 100 feet in length by 15 feet in width, while they have occasionally been worked to a depth of about 700 feet. The most important of these deposits at present being worked is "The Rainbow," which is of considerable size, and is yielding siliceous ore containing 15 per cent. of black tin.

At Watsonville, 6 miles to the west, similar ore bodies occur in sandstones (quartzites) and shales near the junction with granite, where the tin is frequently associated with copper ores.

The Irvinebank Mining Company has a large crushing and tin-smelting plant, 18 miles from Herberton, which is served by a number of mines within an area of sedimentary rocks. The most important mine near Irvinebank is the Vulcan, which has a vertical shaft 1,460 feet deep. A series of disconnected, but in many cases overlapping, bunches of tin-ore of great size and irregular form, have been worked down to a depth of 1,050 feet, and there are indications that deposits occur below that level. This mine has had a most successful history and its future prospects appear to be excellent.

To the south of Irvinebank there are numerous deposits of tin around Spring Hills, Smith's Creek, etc., in sedimentary rocks, while at Mount Garnet about £360,000 worth of copper was obtained from ore-bodies in granite; however, in the lower levels of this mine the ore became zinciferous and iron pyrites replaced the copper ore.

A few miles to the west of Irvinebank the Victoria silver-lead lode, up to 5 feet in thickness, is being worked at a depth of 200 feet, while at Montalbion the same class of ore occurs in irregular bunches in sedimentary rocks.

At Stannary Hills both tin and silver-lead are found in the sandstones near their junction with intrusive quartz-porphyry. The tin-ore occurs in a chlorite gangue in irregularly-shaped bunches having the same character as those in the Vulcan Mine, and has been worked to a depth of about 700 feet.

About 18 miles west of Stannary Hills deposits of wolfram, bismuth, and molybdenite are worked at Bamford Hill, near Petford, and 10 miles south-west of the latter place a considerable area of sedimentary rocks containing tin and wolfram occurs near Koorboora. Many of these deposits are being worked in a small way. Seven miles further west, in Torpy's Crooked Creek Mine, an irregularly-shaped pipe of silver-lead ore is being worked.

At Chillagoe, which is connected by private railway (92 miles long) with the Government line at Mareeba, extensive copper and lead smelting works were erected to treat the products of the district, but although the copper lodes in the vicinity were exceedingly promising on the surface they failed to carry their values to a depth, and most of the Chillagoe Company's Mines have now been closed down, the works being kept going by other mines in the district.

At Mungana, 10 miles from Chillagoe, some very interesting silver-lead deposits occur in the Girofla and Lady Jane Mines. The ore occurs in caverns in limestone rock close to its junction with granite. Some of these ore-bodies are of great magnitude, in one instance as much as 140 feet long by 40 feet wide, and over 300 feet in depth. In the Girofla Mine, considerable quantities of oxidized lead and copper ores were found underneath galena and copper pyrites. This unusual occurrence was probably due to the surface waters having found their way below the sulphides through one of the side channels which are so numerous in limestone caves.

As the contact between the granite and the limestone has been traced for a distance of many miles, it is probable that numerous other deposits of a similar character will be found.

About 23 miles westerly from Mungana, in the Klondyke District, a smelting plant has been erected by the Mammoth Company to treat the copper ores from their mines. These ores also contain an appreciable proportion of gold.

Wolfram Camp is situated about 14 miles north-west from Dimbulah, a station on the Chillagoe Railway. Wolfram, molybdenite, and bismuth are extensively mined here in intrusive greisen close to its junction with slates. The ores occur in bunches and strings in very irregularly-shaped chutes or pipes, similar in their mode of occurrence to the tin-bearing deposits of Herberton. The general trend of the wolfram chutes, however, is northerly and they have occasionally been followed on their dip for as much as 600 feet in that direction. The ores are invariably found in a quartz gangue. The Irvinebank Mining Co. has erected a compact plant at Wolfram Camp for the treatment of these ores. The molybdenite is separated from the wolfram and bismuth by jigs and concentrators, and is finally recovered from the tailings by the flotation process.

From Northcote, 14 miles west of Mareeba, for a distance of about 50 miles in a north-westerly direction, occurs a belt of slates and sandstones containing antimony and gold deposits. Both metals occur in quartz reefs, some of which are interbedded, while some intersect the strata. Some of these reefs contain gold only, in others nearly pure stibnite is found, whilst in others again gold is associated with the antimony ore. The antimony

lodes are worked intermittently, the industry being influenced by the market price of the metal. The sedimentary rocks of this district are traversed by immense dykes which have been much altered by secondary silica.

The wolfram deposits of Mount Carbine are situated about 22 miles west of Mount Molloy railway station. They occur in dykes of coarse pegmatite which have intruded highly altered blue slates near their junction with a granite *massif*.

The pegmatite dykes vary in width from an inch up to 8 feet and they occur in more or less parallel series, though adjoining dykes are frequently connected by smaller ones running in every conceivable direction. The result is a complete network of ore-bodies in which the wolfram is distributed in an average proportion of about 1·3 per cent. The deposits are being worked by tunnels several hundred feet below the top of the mountain, and it seems probable that they will be found to increase in width as greater depth is attained. A large dyke of felsite crosses the mountain near its summit, and intersects the pegmatite series which is evidently older than it.

A very complete crushing and concentrating plant, containing twenty head of stamps, is employed in treating the ore from these mines, which are mainly the property of the Irvinebank Mining Company.

The granite mountains on both sides of Mount Carbine are stanniferous, and on the northern side considerable deposits of alluvial tin-ore are being worked, at intervals, nearly as far as Cooktown.

It may be stated that from 1,000 to 1,500 men are making a living by working alluvial tin within the Herberton, Chillagoe, and Cooktown districts.

The principal difficulty connected with mining in these fields is the scarcity of timber for fuel, which at some of the principal centres costs as much as 23s. per cord. The recent discovery of coal seams at Mount Mulligan, which is only 30 miles north of Dimbulah, a station on the Chillagoe railway, is therefore of immense importance to the mining industry. A railway is now being constructed to the coal-field, and it is safe to say that the cost of fuel at the mines will shortly be reduced by 50 per cent.

Texas.—Near the town of Texas on the southern border of Queensland an important silver-lead mine, called the Silver Spur, has been successfully worked for many years. The ore consists of argentiferous galena with zinc-blende and a little copper pyrites, and it occurs in extensive lenses in Permo-Carboniferous rocks.

Precious Opal is found in Upper Cretaceous rocks in the western districts of Queensland. The most important opal workings are at Paroo, Kyabra, and Koroit. Other localities where the gem has been found include Duck Creek, Bull Creek, Sheep Station Creek, Yowah, and Kynuna.

Sapphire Mining is practised to a considerable extent in the Anakie District about 200 miles west of Rockhampton. The gemstones, which are blue, green, or yellow in colour, occur in a Post-Tertiary alluvial lead, associated with water-worn boulders of basalt, granite, and sandstone. The lead has been traced for a distance of about 27 miles. The original matrix of the sapphires is doubtless the basalt which occurs near the source of the alluvial deposit, and the gems have been set free by the weathering of the rock.

TABLE SHOWING THE QUANTITY AND VALUE OF MINERALS WON DURING THE YEAR 1912, AND TO THE END OF 1912.

Queensland.

Mineral.	Production for Year Ending 31st December 1912		Total Production to 31st December 1912.	
	Quantity.	Value.	Quantity.	Value.
		£		£
Coal	902,166 tons	338,264	14,154,049 tons	5,377,240
Gold	347,946 ozs. fine	1,477,979	17,707,939 ozs. fine	75,218,494
Silver	569,181 ozs.	66,188	13,497,125 ozs.	1,722,319
Copper	23,120 tons	1,698,280	196,163 tons	10,948,399
Tin	3,230 „	364,503	134,593 „	8,199,391
Lead	3,108 „	55,667	39,093 „	534,504
Antimony	..	..	4,181 „	50,953
Opal	..	3,000	..	172,195
Wolfram	626 tons	57,821	8,350 „	735,665
Manganese	308 „	1,281	17,004 „	64,589
Bismuth	197 „	19,261	696 „	111,089
Molybdenite	102 „	17,349	1,415 „	153,703
Limestone	97,175 „	24,176	869,867 „	279,427
Gems	..	40,016	..	226,302
Ironstone	15,526 tons	9,035	259,801 tons	202,780
Scheelite	..	..	20 „	1,772
Fireclay	6,336 „	2,535	23,491 „	9,533
Graphite	..	..	148 „	732
Totals	..	4,175,355	..	104,009,087

4. Tasmania.

The West Coast.

The West Coast of Tasmania consists of very mountainous country composed of Silurian and Pre-Silurian sediments, with granites and other intrusive rocks. The granites are probably mainly responsible for the mineralization which has of late years resulted in the development of a number of important mining fields within this area.

Waratah Mining Field.—The oldest and most important of these fields is that of Waratah, where the Mount Bischoff tin mine has had a most successful history during the last 40 years. Mount Bischoff is formed of Silurian slates and sandstones, which have been intruded by a dyke of topaz-porphyry varying in width from 6 to 150 feet. The general course of the dyke is about north-west and south-east, but near the top of the mountain it makes a complete horseshoe bend. The porphyry contains about ·3 per cent. of tin-oxide, and the slates and sandstones, which have been altered by contact metamorphism, also contain, within a distance of about 60 feet of the dyke, small veins and impregnations of tin-ore. The denudation of the dyke during past ages resulted in the formation of a vast talus of detrital material, which in the early years of the mine's history yielded almost fabulous returns of tin. At the

present time the dyke, the adjacent sediments, and the detrital material are all being removed by open-cast workings in a series of benches, and are sent to the mill in conjunction for an average yield of ·5 per cent. of tin-oxide. There is also a lode known as the Queen lode, which is being worked underground. It intersects both the slates and the dyke, has an average width of 3 ft. 6 in., and yields about ·75 per cent. of tin-oxide. This lode-stuff is also treated with the material from the open cut. From a commercial point of view the mine has a unique history. The company was floated in 1873, the capital actually paid up amounting to only £7,600. In the 40 years which have since elapsed the shareholders have received upwards of £2,400,000 in dividends. At present the total cost of mining, conveying, and milling amounts to only 4s. 11d. per ton of ore. The plant is driven by hydro-electric power, the water having a hydrostatic head of 560 feet.

The Mount Bischoff Extended mine adjoins the Mount Bischoff, and contains a lode averaging about 3 feet in width and yielding ·94 per cent. of metallic tin. The workings extend for a vertical depth of 750 feet, and nearly 20,000 tons of ore are treated annually in a ten-head mill.

The Magnet Silver-Lead mine is situated about 5 miles west of Mount Bischoff. The lode channel, which occurs in dolomite, varies in width from 6 to 100 feet. The lode exhibits a banded structure with veins and lenses of silver-lead-zinc sulphides, with occasionally a little jamesonite and ruby silver ore. The lode channel has been worked for a length of about 400 feet. The mill is worked by water power, a hydrostatic head of 450 feet being available. The concentrates contain 100 ounces of silver, 50 per cent. of lead, and 11 per cent. of zinc.

The Mount Cleveland Tin mine is situated 10 miles from Mount Bischoff, on the Whyte River. A lode of considerable width and said to yield ·9 per cent. of tin oxide has been worked by an open cut, and has been proved at a lower level to consist of pyritic ore.

Osmiridium Mining.—Alluvial deposits of osmiridium are worked in the Nineteen-mile Creek and other tributaries of the Savage River, near Bald Hill, to the north-west of Mount Bischoff. The metal occurs in grains and small nuggets in the crevices of the rocks forming the creek beds. The largest piece yet discovered weighs about 2 ounces. The source of the metal has been proved to be serpentine rock, in which it appears to be sparsely disseminated in grains.

The Tullah Field is situated about 15 miles south of Waratah, and the principal mine is the North Mount Farrell Silver-lead Mine. There are three lodes varying from 5 to 20 feet in width in the property, and they occur in crushed schist near its junction with intrusive porphyry. The ore consists of argentiferous galena with only a trace of zinc-blende. The output is about 2,700 tons per annum of picked ore and concentrates, the former containing 63 per cent. of lead and 75 ounces of silver per ton, while the latter average 53 per cent. of lead and 55 ounces of silver.

In the *Rosebery Field*, near the town of Rosebery, on the Burnie-Zeehan railway, there are three important mines, viz., the Tasmanian Copper Company, the Primrose, and the Hercules. The Tasmanian Copper Company is a misnomer, as they work a silver-lead-zinc mine. The country rock is a

silicious schist and the ore-deposits consist of large interbedded lenses of fine-grained pyritic ore with galena, zinc-blende, and a little fahlerz. The lenses extend for a length of 2,500 feet with a maximum width of 60 feet. Over 30,000 tons of ore have already been extracted, the average contents being 25 per cent. of zinc, 7·96 per cent. of lead, 12·3 ounces of silver, and ·145 ounces of gold per ton. The developed and blocked-out ore reserves have been estimated at 227,300 tons, and the *probable* ore reserves at 773,000 tons.

The *Primrose* is an adjoining mine containing deposits of similar ore, and the two mines are worked, under the one management, by means of tunnels and open cuts.

The *Hercules Mine* is situated at an altitude of 2,800 feet on the slopes of Mount Read, about $4\frac{1}{2}$ miles from Rosebery. It contains three large lenses of sulphide ore of similar character to that of the Tasmanian Copper Company's Mine, the average composition being 28 per cent. of zinc, 8 per cent. of lead, 8 *ounces* of silver, and ·16 ounces of gold per ton, while the most eastern lens also contains a fair proportion of copper. The *probable* ore reserves in the Hercules Mine have been estimated at about 500,000 tons. The future success of these mines appears to depend upon the adoption of a method of treatment which will enable the zinc to be recovered in addition to the other metals.

The *Renison Bell Field* contains a number of tin mines, of which the most important are the Renison Bell, Boulder, Central, Penzance, Dreadnought, and Federal. They are situated near the Renison Bell Station, on the Emu Bay Railway. The principal rocks in this locality consist of slates, tuffs, and intrusive quartz-porphyry. The ore-bodies are composed chiefly of pyrrohotite and iron pyrites carrying cassiterite, and they have been deposited by ascending solutions and vapours along faults which have fissured the country rock in a very irregular manner, causing the lodes to exhibit many branches and flat floors. The slates in the vicinity of the lodes have also been impregnated by veinlets of tin-bearing pyrites. The gangue of the ore bodies consists chiefly of quartz and dolomite. Rich pockets and bands of tin ore are occasionally found in the lodes. The oxidation of the sulphide ores has resulted in the formation of rich stanniferous gossan at the surface, and large quantities of this have been profitably treated. There was also a considerable accumulation of detrital ore on the sides of the hills, and from this the tin was recovered by sluicing. The mill at the Renison Bell Mine contains only ten head of stamps, and the ore at present being treated has an average yield of ·9 per cent. of tin oxide.

The Zeehan Field.—The town of Zeehan is the principal settlement on the West Coast, and possesses important smelting works, besides being the centre of a group of mines. The principal properties in this district are the Zeehan-Montana Cuni, Silver Queen, British Zeehan, Silver King, and Oonah, but at the present time only the two first-named are being worked. At the *Zeehan-Montana Mine* Silurian slates and tuffs form the country rocks, and with these are associated intrusive dykes of stilite. The ore bodies are in the form of north and south fissure lodes, the filling of which is principally composed of siderite with galena, zinc-blende, and pyrites. A series of fault

fissures, locally called slides, with a general north-west and south-east strike, have intersected and displaced the lodes. As the siderite lodes approach the south-western or footwall sides of the slides, they are split up into branches which frequently contain chutes of argentiferous galena. The continuation of the lode beyond the hanging wall of the slide is usually barren until it approaches the footwall of another slide, when similar deposits of galena are met with. The shaft has been sunk to a depth of 800 feet, but so far practically no payable ore has been found below the 500-ft. level. The mine has paid about £180,000 in dividends since 1893.

The *Cuni Mine* is situated 5 miles from Zeehan on the railway to Renison Bell. The country consists of alterations of ferruginous slate and serpentine. Lenses of pyrrhotite occur in the serpentine, and the ore contains about 5 per cent. of copper and 12 per cent. of nickel. The lenses attain a maximum width of 14 feet, and are sometimes 100 feet long. This mine and a similar one adjoining it are at present in the prospecting stage. The ore has been proved at intervals over a distance of about 1 mile

The Mount Lyell Field.—The Mount Lyell Mining and Railway Company's property is situated near Queenstown, about 15 miles from Strahan. The principal mines owned by the company are the Mount Lyell, North Mount Lyell, Comstock, South Mount Lyell, and Lyell Tharsis.

The Mount Lyell ore deposits consists of a huge lens of low-grade pyritic ore of the following composition :—

Sulphur	42 per cent.
Iron	36 ..
Silica	5 ..
Alumina	2·8 ..
Barium sulphate	4·1 ..
Copper	0·4 ..
Silver	1·86 oz. per ton
Gold	·04 ..

The ore-body occurs in tuffaceous schists close to their junction with conglomerate. It is probable that it has been deposited from ascending solutions in a cavity or fissure formed by a fault, and there is evidence, especially on the hanging wall, of its having been enlarged by replacement of the schists. The lens has been worked by an open cut to a depth of 470 feet, and by shafts and levels to a further depth of 350 feet, while bores have proved that it extends to a total depth of 850 feet.

The present ore reserves are estimated at two million tons. The ore is smelted in conjunction with the North Mount Lyell ore in the proportion of 2 tons of the former to 1 of the latter.

The *South Mount Lyell Mine* contains a pyritic ore-body similar to Mount Lyell, and containing ·38 per cent. of copper. It is estimated to contain about 300,000 tons, but has only been opened up on one level at present.

The *North Mount Lyell Mine* is situated about 1 mile from the Mount Lyell. The ore-body is an irregular lens of large dimensions, bounded by conglomerate, and it has the appearance of having resulted from the metasomatic replacement of schist. The ore is silicious, and contains bunches

and impregnations of bornite and chalcopyrite. Its composition is as follows :—

Copper	6	per cent.
Silica	65·70	..
Iron	7·7	..
Sulphur	6	..
Alumina	10·2	..
Barium sulphate	1	..
Silver	1·15 oz. per ton.	
Gold	A trace	

The lens has already been proved to a depth of 1,100 feet, and has been stoped for a length of 1,000 feet at the No. 10 level.

The ore reserves in the mine are estimated at 1,000,000 tons. The ore from the Mount Lyell and North Mount Lyell Mines is smelted, in conjunction, in blast furnaces, in the proportion of 2 tons of the former to 1 of the latter. The matte is treated locally in converters, and the resulting blister copper is refined at the Port Kembla Works, New South Wales.

The North Mount Lyell ore deposit extends into the *Comstock* section on the north. The *Lyell Tharsis* is a similar deposit of lower grade occurring in the schist; it carries about 2 per cent. of copper.

The North Coast.

The Blythe River Iron Ore Deposit is situated about 10 miles from Burnie, on the North Coast. The ore body consists of a huge vertical bed or lens of hematite having a north-east and south-west strike for a distance of over a mile, and apparently interbedded with slates and sandstones of pre-Silurian age. The Blythe River has cut its way through the deposit which extends up both sides of the gorge. It has been estimated that there are at least 20,000,000 tons of ore in the deposit above the level of the river. The deposit has been sampled over the whole outcrop, and the analysis gave an average yield of 63·259 per cent. of iron, 7 per cent. of silica, and 0·036 per cent. of phosphorus. Nothing has yet been done towards utilizing this valuable deposit of iron ore.

Oil Shale Deposits of the North Coast.—In the Mersey district there are deposits of a peculiar resinoid shale known as Tasmanite, which is believed to be of considerable commercial value as a source of fuel oil. The shale occurs as a seam in the Marine Sandstones of the Permo-Carboniferous series, and in the neighbourhood of Latrobe it has an average thickness of 1 ft. 6 in. It is a brownish laminated rock consisting of sandy mud through which are disseminated numerous minute yellow resinous-looking discs, which are believed to be sporangia. The peculiarity of the resinoid discs is that they contain about 2 per cent. of sulphur in combination with their carbon and hydrogen.

The average composition of the shale is as follows :—

Moisture	1·10
Volatile matter	29·69
Fixed carbon	3·11
Ash	66·10
	100·00
Sulphur	2 per cent.

The shale yields, by destructive distillation, from 30 to 50 gallons of oil per ton. Mr. Twelvetrees, Government Geologist, estimates that there are in the Mersey district 12,000,000 tons of shale containing 2,000,000 tons of crude oil, equal to $1\frac{1}{3}$ million tons of fuel oil.

The Latrobe Shale and Oil Company are erecting retorts for the production of oil from Tasmanite.

The Middlesex Field, situated near Railton, contains deposits of silver-lead, and also tin, bismuth, and wolfram. In the *Round Hill Mine*, 16 miles from Railton Silver-lead lodes occur in slates close to their junction with conglomerates. About 1,000 tons of concentrates containing 56 per cent. of lead and 33 ounces of silver per ton have been produced.

The *Shepherd and Murphy Mine*, 28 miles from Railton, contains narrow lodes in quartzite and garnet rock close to their junction with intrusive granite. The lodes contain cassiterite, bismuth, and wolfram impregnations in a quartz gangue. Nearly 40,000 tons of ore have been crushed and 671 tons of concentrates produced.

Beaconsfield Mining District.

The celebrated *Tasmania Gold Mine* is situated at Beaconsfield on the west side of the Tamar. Up to the end of 1912 this mine had treated 982,587 tons of stone for a yield of 808.255 ounces, and had paid £772,671 in dividends. The last dividend was paid in 1905. Grubb's shaft is down to a depth of 1,500 feet, and work is being carried out at this level.

The lode occurs in slates, conglomerates, and sandstones, and was 40 feet wide on the surface, but became narrower and poorer in depth. It is an exceptionally wet mine, and is equipped with one of the finest pumping plants in the world.

At *Anderson's Creek*, near Beaconsfield, there are deposits of hematite and magnetite containing a considerable proportion of chromium, which has hitherto interfered with their use, for smelting purposes. There are probably several million tons of ore in these deposits.

The *Lefroy Gold Field* is situated 7 miles east of George Town, on the Tamar River. Auriferous reefs and alluvial deposits have been worked with considerable success in the past on this field. The total amount of gold won amounts to over 200,000 ounces, and dividends amounting to nearly £300,000 have been paid, but the gold chutes have failed below a depth of 400 feet. At the present time the prospects of successfully working the deep alluvial (basalt-covered) leads appear to be hopeful.

The Tin-Fields of the North-East Coast.

A considerable area of tin-bearing granite occurs near the north-east coast, and tin mining has been carried on here with much success for over 30 years. The tin-oxide is found as impregnations and small veins in the granite and greisen, and the decomposition and denudation of these rocks has resulted in the concentration of large quantities of stream tin in the Tertiary basalt-covered deep leads along the course of the Ringarooma River, and also in the Pleistocene and recent alluvial deposits. The shallow alluvials were of course worked first, and the tin was subsequently traced down into the deep leads. The latter are being successfully worked by hydraulic sluicing in such mines as the Arba, Briseis, Pioneer, Garibaldi, and Clifton

Creek. The Briseis has removed 4,746,000 cubic yards of overburden and 4,600,000 cubic yards of drift for a yield of 9,589 tons of stream tin, valued at £1,125,700, and has paid dividends amounting to £380,000. The Pioneer, which is worked by hydro-electric power, has treated 5,720,900 cubic yards of gravel for a yield of 4,832 tons of stream tin, and has paid £254,095 in dividends.

A most remarkable example of economical mining is supplied by the *Anchor Tin Mine* at Lottah, where the tin is being won from the solid granite or greisen. The ore bodies are covered by an overburden of as much as 100 feet, in places, of barren granite, which, being more or less decomposed, is partly removed by hydraulicing. The Anchor Mine has crushed 1,200,000 tons of rock for an average yield of less than 3½ lbs. of tin oxide per ton. The cost of mining, crushing, and concentrating, during ten years' work, has been from 2s. 6d. to 3s. per ton of stone. The ore is worked by open cut, and hydraulic power is employed for the mill.

The Scamander Field.—A few miles from Scamander, on the east coast, there are low grade deposits of tin, copper, wolfram, silver, and gold. None of these are at present being economically worked, though prospecting operations are being carried out in tin-bearing quartzites close to their junction with granite.

In the *Mathinna Field,* 17 miles north of Fingal, a number of quartz reefs was successfully worked for some years. The principal mine was the *New Golden Gate,* which was tested to a depth of 1,800 feet, where the ore ceased to be payable. Between 1888 and 1904 the mine yielded 232,225 ounces of gold, from 277,393 tons of stone, and paid £355,200 in dividends.

Coal.

Tasmania is not so fortunately situated as the other eastern States in regard to her coal resources The coal measures of Tasmania are of two ages, viz., (1) Permo-Carboniferous ; and (2) Mesozoic.

(1) The Permo-Carboniferous measures are characterized by thin coal seams (from 1 to 2 feet in thickness) of fair quality, though high in moisture and sulphur. The average composition of the coal is as follows :—

Moisture	12·9
Volatile hydrocarbons .. .	36·5
Fixed carbon	46·6
Ash	4·0
	100·00

It is suitable for domestic use and for steam raising, but contains an excess of sulphur. The principal localities where it occurs are the Mersey Coal-field, near Latrobe, and the Preolenna Coal-field, 18 miles from Wynyard, but it is not being worked at present.

(2) The Mesozoic coal measures cover a large area of the State, but unfortunately they have been much faulted and dislocated by intrusions of diabase. They contain seams up to 12 feet in thickness, but the workable coal seldom exceeds 6 feet. The quality of the coal varies considerably, but it is usually high in ash and moisture ; it is useful for domestic purposes, and

is also employed in the locomotives on branch railways. The two principal collieries working this coal are the Mount Nicholas and the Cornwall, near St Mary's, which have an annual output of about 30,000 tons each. Mr. Twelvetrees estimates the probable coal reserves as follows:—

Permo-Carboniferous	13,000,000 tons
Mesozoic	54,800,000 ,,
Total	67,800,000 tons

TABLE SHOWING THE QUANTITY AND VALUE OF MINERALS WON DURING THE YEAR 1912, AND TO THE END OF 1912.

TASMANIA.

Mineral.	Production for Year ending 31st December, 1912.		Total Production from 1880 to 1912 inclusive	
	Quantity.	Value.	Quantity.	Value.
		£		£
Gold	37,973 ozs.	161,300	1,738,661 ozs.	6,914,132
Silver-lead ore	90,124 tons	309,098	950,613 tons	5,488,286
Blister copper	5,136 ,,	430,965	122,912 ,,	9,728,833
Copper matte	..	..	6,227 ,,	133,736
Copper and copper ore ..	1,391 tons	9,479	35,135 ,,	536,014
Tin	3,714 ,,	543,103	109,915 ,,	10,884,922
Iron ore	..	..	42,762 ,,	25,701
Coal	53,560 tons	24,568	1,312,460 ,,	1,057,700
Wolfram	66 ,,	6,601	402 ,,	36,033
Bismuth	7 ,,	2,646	43 ,,	14,961
Asbestos	..	..	374 ,,	521
Shale	..	..	864 ,,	464
Osmiridium	779 ozs.	5,742	1,170 ozs.	8,160
Unenumerated prior to 1894 ..	..	..	..	31,988
Total	..	1,493,502	..	34,861,451

5. Western Australia.

The State of Western Australia occupies the western third of the continent, and is estimated to embrace an area of 975,920 square miles.

The inception of active mining operations in Australia dates from the year 1842, when lead and copper lodes were first discovered and worked at Waneranooka in the Northampton district of Western Australia. Since then the State has produced mineral products the total value of which, up to the end of 1912, amounts to £113,660,065; of this 54·5 per cent. has been obtained from the East Coolgardie Gold-field, which contains the important gold mining centre of Kalgoorlie. The real mining history, however, dates from the year 1893.

The mineral fields are numerous and scattered over a very wide area. The total area of the proclaimed mineral fields amounts to 329,828 square miles; the position of these, as legally defined by the authorities, has been shown on the map of Western Australia included in the Report of the Department of Mines for the year 1912. The legal boundaries of the mineral fields, however, bear no relation whatever to the geological boundaries.

The principal mineral products of greatest importance in Western Australia, arranged in order of value, at the end of 1912, are gold, copper, coal, tin, lead, and phosphates. The metals and metalliferous minerals make up by far the greater proportion of the value of the output, being over 98 per cent. of the total.

The south-western corner of the State from Israelite Bay to Cape Leeuwin, and as far north as latitude 25° south, is a more or less broken tableland from which rise isolated hills and ridges of metamorphic and crystalline rocks to which a pre-Cambrian age has been assigned. This plateau forms the chief mineral region of the State. Isolated patches of variable extent of these older pre-Cambrian rocks rise from beneath the newer strata in the north-west and Kimberley divisions, and are as important from the mineral stand-point as in the south-western plateau.

The pre-Cambrian rocks are remarkable for the variety of useful and valuable minerals they contain, numbering up to date no less than 196.

There are sound reasons for knowing that the major portion of this pre-Cambrian plateau has been a land surface since early Palæozoic times, and having had such a peaceful geological history, there has not been very much opportunity for mineralization, hence the valuable ores have a very wide distribution instead of, with certain notable exceptions, being concentrated into very rich deposits. Whilst this is so, the results obtained by geological exploration, prospecting, and mining operations indicate quite clearly that the mineral industry of the State will not only be progressive but great. The future of gold mining in Western Australia, however, must in a great measure depend upon the exploitation of its low-grade deposits of which there are very many.

Geologically the pre-Cambrian plateau is characterized by a more or less complicated structure. The plateau forms one general geological province in which the nature and mode of occurrence of the mineral deposits are more or less identical throughout. The interdependence of the mineral belts on the geological structure is exceptionally well marked in all parts of the State. The rocks are of very different types; many of them are in a crystalline condition and form coarse crystalline schists and gneiss as well as basic rocks, which have been more or less crushed, foliated, and completely converted into greenstone schists. The basic rocks comprise gabbro, dolerite, porphyrite, epidiorite, pyroxenite; in some localities these basic rocks can be seen passing by scarcely perceptible gradations into hornblende schists and allied rocks. Some of these older rocks are of sedimentary origin and are practically unaltered; others are quartz and mica schists, and in certain localities are cleaved conglomerates, some of the pebbles in which consist of a pre-existing conglomerate from a very much older series. The less altered members of these ancient sediments consist of a great variety of types of indurated slates, quartzites and conglomerates, together with igneous rocks, which probably represent lavas and ashes.

These older rocks are invaded by batholiths and veins of granite and allied rocks, which in many parts of the State occupy very large areas. The old granitic rocks are traversed by many large ice-like quartz reefs, which rise like walls to considerable altitudes above the surface. The mode of occurrence, etc., of these large quartz masses point to their being of igneous

origin, representing the final product of the differentiations of a granitic magma, its ultra-acid portion. These older granitic rocks are of considerable importance by reason of the fact that they form the matrices of the tin and allied deposits of the State.

The mineral deposits of Western Australia occur in areas generally as more or less parallel belts of relatively narrow lateral dimensions, though in certain localities they appear as small isolated areas or patches. These narrow well-defined belts have a general north-west and south-west direction, with occasional divergencies of several degrees on either side. The ore deposits in these belts or zones, owing to dynamo-metamorphic processes, do not crop out in long lines, but are cut up into relatively short lenticles, arranged *en echelon*.

There are in all, 24 proclaimed mineral fields in the State, though there are in addition other areas which have been proved to be mineral-bearing, but which have not as yet been brought within the limits of any legally defined mineral field. Most of the mineral fields of Western Australia produce other metals besides gold, though in nearly all cases that is by far the most important product.

Kimberley Gold-field.—This, the most northerly gold-field in the State, discovered in 1882, is of historical importance, though it has not been a very notable gold producer.

The gold belt of Kimberley, a succession of crystalline schists of remarkable persistence, has been proved to extend from Denham River to Mount Dockrell, also in the Mueller Range, from whence it strikes north-westward along the foot of the King Leopold Range to King Sound.

This belt of rocks, micaceous and talcose schists, gneiss, and granite, varies in width from 10 to 30 miles, and has been shown to have a horizontal extent of at least 120 miles.

Mining and prospecting operations have been confined, however, to only six, more or less, isolated centres. These up to the end of 1912 have only produced 17,012·75 ozs. of fine gold.

Pilbara Gold-field.—The Pilbara Gold-field contains several gold and tin-bearing areas, scattered over different portions of the district; economically, however, the auriferous deposits have proved up to the present to be the most important.

The geographical position of the various gold-mining centres shows a zonal development of the auriferous deposits which may be divided into six main and distinct groups, viz. :—

- (*a*) Lalla Rookh.
- (*b*) North Pole, Talga Talga, Bamboo.
- (*c*) Marble Bar, Warrawoona, Yandicoogina, Mount Elsie, Boodalyerri;
- (*d*) Nullagine, 20-mile Sandy, Mosquito Creek;
- (*e*) Tambourah, Western Shaw; and
- (*f*) North Shaw.

The length of the Lalla Rookh Belt has not yet been defined, but it does not appear to be less than 30 or 40 miles. The North Pole, Talga Talga, and Bamboo Belt is 50 miles in length. The Marble Bar, Warrawoona, Yandicoogina, Mount Elsie and Boodalyerri Belt has a proved extent of

about 80 miles. The Nullagine, Middle, and Sandy Creek zone is known to extend for a distance of at least 40 miles, and there are strong geological reasons for the belief that it continues much farther to the east and may possibly cross the upper reaches of the Oakover River. The Tambourah and Western Shaw Belt has not as yet been accurately defined. but it does not appear to be less than about 30 miles in length, whilst that of the North Shaw has only been proved to extend for a few miles.

The general direction of these auriferous belts almost everywhere coincides with the strike of the schists which, with one or two exceptions, invariably form the matrices of the gold-bearing reefs. The prevailing dip of the belts coincides with the general trend of the main structural features of the district. Their width naturally varies, and in the three most northerly zones the width cannot be defined owing to the fact that one of the boundaries is invariably marked by a powerful fault, which throws down the newer beds against the schists.

Quartz reefs occur in great abundance all through the schistose rocks, as well as to a more limited extent in the areas occupied by the granitic rocks. The quartz reefs are of two distinct types, viz., white quartz reefs and laminated quartz and jasper veins approaching very closely the hematite-bearing quartzites (?) which invariably form a conspicuous feature in most of the gold-fields of the State. Some of the laminated quartz veins range from almost pure quartz, through banded jaspers, with crystals of magnetite, to bands appearing to the eye to be virtually pure hematite. The quartz reefs, of what may be called the massive types, occur plentifully in both the schists and the granites. They invariably occur along the planes of foliation (? bedding) of the schists, or, at any rate, cut them at a low angle.

The auriferous reefs cannot be said to be long, and are, as a rule, small, though they occasionally swell out into large lenticular masses. Some of the reefs have been traced along the outcrop for over 2,000 feet, and have swelled out to masses measuring about 15 feet across.

In addition to the gold derived from quartz reefs, the conglomerates at the base of the Nullagine Series have been mined in two localities—Nullagine and Just-in-time. It is noteworthy that the base of the series has only proved auriferous in those places where it lies upon that portion of the underlying formation which carries auriferous quartz reefs.

At Nullagine the auriferous strata occur through a thickness of about 300 feet of grits, sandstones, and conglomerates, which form the lowest portion of the series. The auriferous conglomerate is of sedimentary origin, and is made up of rounded and subangular fragments of the underlying strata. Those portions of the strata which have proved to be gold-bearing are those which are largely impregnated with the oxides and sulphides of iron, and which lie between a well-marked fault and a greenstone dyke. Mining operations have, up to the present time, been confined exclusively to the oxidized zone of the conglomerate and to very limited and shallow depths. The available evidence regarding the origin of the gold seems to indicate that it is a secondary and not an original constituent of the conglomerate; and owed its introduction to the percolation of mineral-bearing solutions down the most porous portions of the conglomerate, this condition being facilitated by the downward inclination of the bedrock, and possibly

accentuated in part by the folding which the strata have undergone. Numerous dry-blowers have been at work for a number of years over that portion of the conglomerate from which the crushings have been obtained, and have acquired a considerable quantity of gold, of which the published figures afford no clue. In all probability one-half of the "alluvial" gold from Nullagine may be legitimately claimed to have been derived from the escarpment of the conglomerate.

At Just-in-time, 8 miles to the south of Marble Bar, another auriferous conglomerate at the base of the series has been worked. In many respects the auriferous conglomerate resembles the ferruginous bands as developed at Nullagine, and varies in thickness from an inch up to 5 feet. Certain portions of it contain a sufficient quantity of iron oxides to give quite a distinctive character to the rock. The auriferous conglomerate of Just-in-time, is, however, not of any very great horizontal extent, nor does it appear to penetrate to any considerable depth. As has been the case at Nullagine, the sloping ground at the foot of the escarpment has yielded considerable quantities of gold to the dry-blowers, but, unfortunately, it did not appear to have been possible to keep a separate record thereof. Most of the gold obtained in this way owed its origin to the disintegration of the conglomerate.

The Pilbara Gold-field has, up to the close of 1912, produced 166,914·21 ozs. of fine gold, of which 3,264·59 ozs. have been obtained from the conglomerate.

West Pilbara Gold-field.—The West Pilbara Gold-field is of some historical interest in that it contains one of the oldest mining centres in the State. The mining history of the field opened with the discovery of rich copper and lead deposits in the vicinity of Roebourne during the year 1872, though it was not until five years later that auriferous quartz reefs were reported and opened out. Since then West Pilbara has turned out 54,172·84 tons of copper ore and 22,601·98 ozs. of fine gold in addition to small quantities of tin and iron ore. The area of the West Pilbara field, as legally defined by the authorities, embraces 9,480 square miles, of which, however, only about 1,500 are occupied by mineral-bearing formations, for by far the largest portion of the field is covered with the andesites, dolerites, conglomerates, quartzites, and shales of the Nullagine Series, which effectually conceal the older rocks beneath. The remaining portions of the field consist of granite and gneiss, together with a series of metamorphic rocks of both sedimentary and igneous origin, and a series of basic dykes of pre-Nullagine age. The valuable ore deposits of West Pilbara are confined to the northern and eastern portions of the field.

The most important gold mining centre is Station Peak, situated on the head waters of the Peewah River. In its geological structure, Station Peak is comparatively simple, consisting of a highly inclined series of sedimentary rocks invaded by basic and acidic dykes. The sediments are traversed by a dyke of quartz-dolerite, which varies from 800 to 1,000 feet in width; this dyke forms the most important economic feature in the geology of the field, owing to its forming the matrix of the reefs which up to the present time have proved to be auriferous The gold-bearing quartz reefs of Station Peak have a more or less parallelism, which is roughly approximate to the general strike of the dolerite. The reefs vary in thickness from ⅛ inch up

to as much as 20 feet, whilst the maximum length attained by the most important is 4,000 feet. These reefs have yielded 9,382 ozs. of fine gold, from the milling of 9,993 tons of quartz. This yield forms nearly one-half of the total gold-output of the West Pilbara Field.

Pre-Cambrian deposits of several types, containing copper, gold, antimony, etc., are found in several parts of the district, associated with those bands of laminated quartzite which make such conspicuous features in the structural geology of the field.

Up to the end of 1912, the West Pilbara Field has produced 22,601·98 ozs. of fine gold.

Ashburton and Gascoyne Gold-fields.—The Ashburton and Gascoyne Gold-fields are situated on the headwaters of the Ashburton and Gascoyne Rivers respectively. They do not embrace any large area, and have not so far been very noteworthy gold producers. There is a great diversion of geological formations, though in its broad outlines the geological features of the gold-fields are fairly simple.

As is the case in West Pilbara by far the larger known area is made up of representatives of the Nullagine Series, which constitute the high plateau breached by the Ashburton River. The two fields contain several minor gold-bearing areas, scattered over widely separated localities. The auriferous deposits are of diverse types, and possibly of different geological ages.

At Bangemall, on the Lyons River, in the Gascoyne Gold-field, the productive auriferous area lies between two beds of micaceous quartz schist, forming the legs of a denuded anticline, which has a decided pitch to the south-east. These two bands trend across country for considerable distances, and are associated with auriferous quartz veins. The most important feature, however, is the saddle reef nature of the quartz veins, which bears a striking resemblance to those of Bendigo in Victoria.

There are some sound geological reasons for believing this auriferous belt to extend as far westward as Mount Egerton.

The gold-bearing zone of the Ashburton Valley is defined to the escarpment of the Nullagine Series which flank both walls thereof, and has been estimated at 10,000 square miles. There are five centres at which mining operations have at one time or another been carried on. The primary gold deposits are contained in a highly inclined series of sedimentary rocks, quartzites, grits, and slates, having an average strike of 122 degrees. The beds are in most cases traversed by quartz reefs of varying dimensions and interrupted continuity. The strata are disposed in a series of more or less acute folds, and the reefs, which occur on the flanks of the arches, may possibly represent the legs of saddle reefs now modified by denudation. The coarse gold obtained from many of the gullies doubtless owed its origin to the disintegration of the quartz reefs.

Up to the close of 1913 these two fields have produced 9,411·04 ozs. of fine gold.

Peak Hill, Murchison, Yalgoo, and Yilgarn Gold-fields.—The dependence of the mineral-bearing zones on geological structure is exceptionally well-marked in the three most westerly, of what may be called the Central Gold-fields. The important ore deposits are confined largely to a diagonal belt extending from Mount Beasley, on the north, to Mount Singleton, near the

extremity of the westernmost arm of Lake Lefroy, on the south. The mines of the belt yield almost entirely gold, though there are a few localities from which small quantities of copper and tin have been obtained and are not so far of any great importance. The geological structure of the mineral zone is remarkable for its uniformity; it may be described as a series of more or less persistent zones of schists and allied metamorphic (in parts sedimentary) rocks forming a distinct lithological province. The schists and their associated rocks are remarkable for their persistent strike and horizontal extent, one belt alone having been proved to extend for at least 60 miles. These zones of schists are everywhere surrounded by granite, which seems to be of two distinct geological ages, viz., an older, which has undergone the same dynamic alteration to which the schists owe their origin, and a much newer, which penetrates the older granite as well as the schists. The schists are associated with diabase (dolerite), pyroxenite, and allied rocks, and there are sound reasons for believing that some at any rate of the schists merely represent crushed or plated out varieties of the basic rocks. Some of the basic rocks are traversed by belts of laminated quartzes intersected by numerous faults, which are of considerable economic importance by reason of the fact that it is along these fault lines that rich shoots of gold often occur.

The principal mining centre along this belt is Day Dawn, where one of the largest solid quartz reefs (the Great Fingall) mined anywhere is situated. This reef, which has an outcrop of about 30 chains in length, produced up to the end of 1912, 1,080,415 ozs. of fine gold, and 150,470 ozs. of silver from the milling of 1,642,089 tons of ore. The outcrop, when first discovered, was of considerable size, and rose above the general level of the surface in a series of camel-backed ridges, from 10 to 20 feet in height.

The average dip of the reef is about 60 degrees to the south westward, and its maximum thickness 40 feet. The lowest vertical depth at which the reef has been mined is 2,342 feet. The great Fingall Lode is more or less transverse to the general trend of the "Auriferous Series," and occupies a relatively narrow belt of schistose amphibolite which is traversed by basaltic dolerite and porphyry dykes. The quartz below water level contains small quantities of pyrites, pyrrhotite, mispickel, zincblende, galena, and a little copper pyrites.

The mineral zone, which traverses the Murchison Gold-field, seems to be continuous southward through the Yilgarn Field, of which the official centre is Southern Cross. The first authentic gold find on the Yilgarn Gold-field was made at Ennuin in 1887; this was shortly afterwards followed by the discovery of the pioneer mine, Frasers, at Southern Cross, which has been continuously worked for over 25 years.

The Frasers Lode occupies a belt of considerable length, and it outcrops at intervals in the form of lenses occurring in a shear zone of amphibolite and its derivatives. This shear zone contains more or less pyrites, and it has been found the gold values bear an intimate relation to the extent of its mineralization. The lode is intersected, in a direction at right angles to the general trend, by dykes of pegmatite granite, and where this occurs there is a slight impoverishment of the lode at the points of contact.

The Yilgarn Gold-field has, since its discovery, produced 407,770 ozs. of fine gold, of which the Frasers Lode alone yielded 172,471 ozs. of fine gold. These banded ferruginous quartz lodes when seen below the oxidized zone pass into schists with pyrites with thin seams of magnetite and pyrrhotite. The Mount Caudan Bore, put down in what is regarded as the southerly extension of the Frasers Lode ore channel, passed through 100 feet of massive pyrrhotite at a depth of 600 feet from the surface. The pyrrhotite, however, contained only a minute trace of gold.

The mineral zone, in which this persistent ore channel lies, is of considerable horizontal extent; it is really constituted of a series of very long belts arranged more or less *en echelon*, and encased in basic rocks, some of which may be of sedimentary origin. The larger area of the field is of granite, which is of distinctly later origin than the greenstones,which are invaded by dykes of pegmatite and veins of granite quartz.

The Yilgarn Gold-field has, since the inception of mining operations, produced 407,770 ozs. of fine gold.

The Eastern Gold-fields.—There is a remarkable uniformity in the geological structure and mode of occurrence of the mineral deposits of the Eastern Gold-fields. The auriferous districts are of interest on account of their wide distribution and regular mode of occurrence of the gold-bearing deposits.

Very large areas of the surface are covered with a variable thickness of recent accumulations, which are sometimes solidified into cement.

The staple formation, however, is granite, gneiss, and a series of schistose rocks, some of which are of sedimentary origin; associated with these are large areas of basic rocks of different types and possibly of different origins. As in other portions of the State the general strike of the schists is north-west; they are very often vertical or at any rate inclined at high angles. Gold occurs generally at no great distance from granite intrusions and along shear zones or shatter belts containing quartz veins or quartz lenses. These zones or belts are often cut by pegmatites and porphyry dykes, which in places have been fractured and the resulting cracks filled with quartz. The acid dykes are often impregnated with iron pyrites which is occasionally auriferous. The schistose rocks are often associated with hematite-bearing quartzites, some of which might be concentrated into high grade iron ores. The proportion of oxide of iron in these rocks varies from practically pure hematite to a pure quartz rock, often permeated by secondary silica which has also penetrated the surrounding rocks. These banded quartzites are occasionally auriferous.

In the North-east Coolgardie Gold-field, considerable interest attaches to the alluvial leads, the most prominent of which is the North Lead at Kanowna. This lead lies in an old water-course carved out of the older rocks, and has been proved to be not merely a simple isolated run of auriferous gravel, but part of a series of old stream deposits. The width of the North Lead varies from 2 to 80 feet, whilst the thickness of the deposit in the old channel varies from a few inches up to 90 feet. The fall of the lead is about 40 feet to the mile. The deposit consists of surface loam, underlaid by a gravelly ironstone, often partially cemented by kaolin and oxide of iron into solid rock; beneath this lies a bed or beds of practically pure kaolin ("pug") and a varying

thickness of a pebbly quartz wash. The quartz wash is occasionally cemented by secondary silica into a hard compact quartzite. Most of the gold in the North Lead has been won from the quartz wash, although the overlying kaolin and ironstone gravel have also yielded fair quantities. The ultimate derivation of the gold in the North Lead is from the quartz veins and lodes (upon which the wash directly reposes in places) by which the fundamental rocks are traversed. The gold is not exclusively in the form of grains, scales, etc., but is found occurring in the quartz pebbles themselves. In addition to the undoubtedly detrital fold, there is another massive, arborescent or coarsely crystalline form which occurs, filling certain irregular cracks and covering cleavage planes or shrinkage cracks so as to prevent the appearance of painted surfaces. The mode of occurrence, associations, and character of this gold all point to a secondary origin, and it is of importance to note that this secondary gold has been deposited from solution, not only in the alluvium and other superficial deposits, but also in the zone of decomposition of the bed-rock. These secondary forms of gold, which result in the superficial enrichment of many gold-bearing deposits, are a not uncommon feature in the mineral fields of the State.

The East Coolgardie Gold-field, the most productive in Australia, which has yielded £13,364,384 of gold, or about 55 per cent. of the total yield of the State, embraces an area of 632 square miles. The principal mining centre on the gold-field is Boulder, the wealth of which coupled with the skill which directs both the mining and metallurgical operations, has raised Western Australia to the front rank of gold-mining countries in the British Empire.

The productive area of Boulder comprises a relatively small block of ground, which by reason of the richness of the lodes by which it is riddled, has become known throughout the world as the "Golden Mile." This area includes the Great Boulder, Ivanhoe, Golden Horseshoe, Perseverance, Oroya-Brown Hill, Associated, and Lake View Consols Gold Mines. The deepest shaft is over 2,800 feet vertically below the surface, and the country laid open by mining for investigation amounts to several miles, whilst the rocks have been riddled with bore-holes in all directions, thus affording opportunities for the scientific study of many of the rocks in critical localities and in their relation to the ore deposits, such as are hardly to be found in any other single mining field on the globe.

The rocks of Kalgoorlie and Boulder consist of :—(*a*) Ancient sedimentary rocks; (*b*) older greenstones (calc-schists and fine-grained amphibolites); (*c*) newer greenstones (quartz-diabase and coarse-grained amphibolite); (*d*) peridotites; (*e*) porphyrites; and (*f*) quartz and felspar porphyries.

The ancient sedimentary rocks consist of shales, soft sandstones, and conglomerates and boulder beds, associated with what appear to be interbedded lava flows. These sedimentary rocks have a general north-north-west trend, and an average dip of about 80 degrees to the west. They cover a very wide extent of country and have been found near Coolgardie in the west, and Kurnalpi on the east, whilst a similar series of metamorphic sediments have been found to the southward at Norseman on the Dundas Field, where they are intersected by a large number of quartz dykes which form the apophyses of the large granite mass lying to the east of the Norseman auriferous belt.

The sedimentary series of Kalgoorlie are traversed by banded jasperoid and hematite quartz, of that type which forms such a conspicuous feature in the geology of the sedimentary area of Uaroo, in the Ashburton watershed. There seems to be some reason for believing the Kalgoorlie sedimentary rocks to be divisible into two distinct series of different geological age, and distinctly newer than the complex which forms the axis of the Boulder auriferous belt.

Of the rocks of the Boulder-Kalgoorlie igneous complex, the quartz diabase is the most important as it is within this and its alteration products that the principal gold-bearing deposits at present known occur. The quartz diabase is as a rule massive, though owing to the dynamical and concomitant chemical alteration which it has undergone, the rock occasionally assumes a more or less schistose phase.

The principal effect of the chemical alteration has been the extreme carbonating which has gone on over certain portions of the mass, this being naturally greatest where the shearing of the rocks has been most pronounced. The diabase, owing to this chemical alteration, has been converted into an indefinite mixture of carbonates of lime, iron, and magnesia, with some residual silicates and a good deal of secondary and some original quartz. The carbonating is often of considerable extent and has been proved to be fairly deep seated, having been noticed at depths of over 2,000 feet.

The ore deposits of the field form relatively narrow bands, trending generally north-west and south-east. Many of the ore lenses are of great length, and in some cases of considerable breadth; at times, however, the lateral continuity of the lenses is interrupted by overthrust and normal faults of very variable downthrow. The principal lode minerals, in addition to gold and tellurides (calaverite, petzite, sylvanite, hessite, coloradoite, and altaite) are iron-pyrites, marcasite, chalcopyrite, tennantite, asbolite, carbonates (of iron, lime, and magnesia), sulphates (of lime and magnesia), iron ore (haematite, magnetite, ilmenite, etc.), tourmaline, chlorite, albite, rutile, etc. Next to the gold and tellurides, iron pyrites is the most important of the lode minerals; the grain or texture of the pyrites seems to bear some intimate relationship to the gold contents, and it has been noticed that the finer the grain the higher the gold values.

Copper Fields.—The known workable deposits of copper occurring in Western Australia are everywhere met with in areas which have been subject to violent earth movement and concomitant volcanic activity. They all show more or less similarity in their associations, mineralogical characters, and structural relations.

Copper mining, however, is not as yet a very important feature in the mineral production of the State, though the State's total output of copper ore up to the end of 1912 amounts to 185,935·08 tons. Copper ores, however, are widely distributed throughout the length and breadth of the State, but owing to a variety of causes have been worked only in a very few districts. The principal sources of copper are West Pilbara, Mount Morgans, and the Phillips River; the largest output, 72,190 tons, being from Phillips River, 51,172 tons from West Pilbara, and 47,860 tons from Mount Morgans.

The Phillips River field consists of a series of metamorphic sedimentary rocks, associated with a complex series of crystalline rocks, which latter are

of igneous origin, and range from granite to serpentine with their cleaved and schistose varieties. The lodes of the field, which have a uniform strike of east-north-east, are of two types; the first being basic cupriferous dykes, and the second siliceous or ferruginous deposits, of what may be called the shear-zone type.

The Mount Malcolm Copper Mine at Eulaminna (late Anaconda) in the Mount Morgans district, has yielded nearly one-third of the copper production of the State. The whole of the copper-bearing belt is in basic rock, with quartz, jasper, and ironstone veins, which show little or no copper at the surface. The ore has been concentrated into zones of enrichment, in reality bonanzas, three of which have been worked at the surface to comparatively shallow depths. Nothing very definite is known of the precise geological relationships of the Anaconda copper deposit.

The West Pilbara Gold-field has been a large producer of copper, which, however, has been obtained principally from one property, the Whim Well Copper Mine. This lode has proved to be the largest and richest copper ore body yet discovered in Western Australia in the oxidized zone. The country rock in which the deposit is situated is a weathered talcose schist, associated with beds of a sedimentary origin. The ore deposit is a very flat-lying lode, conforming to the bedding of the enclosing schist country, which has a general strike of north-west and south-east.

Tin Fields.—There are only two districts in Western Australia in which tin mining has been carried on, viz., Greenbushes and Pilbara. From the former locality 8,477 tons of tin ore have been raised, whilst the latter produced 4,886 tons; a small quantity, however, has been obtained from the Murchison Gold-field.

Wherever the tin deposits of Western Australia have been examined they are invariably found to fall into two distinct geological categories:—

1. Superficial deposits, which include (*a*) alluvial deposits; and (*b*) residual sands, gravels, etc.; and
2. Deposits in country rock, which embrace (*c*) tin-bearing granite and allied rocks; and (*d*) tin-bearing dykes.

The alluvial deposits which are the most important of any yet opened out in the State, vary very largely in nature and range from an extremely hard ferruginous conglomerate to a stiff clay or loose sand or gravel. The tin-stone in the first-named is often extremely coarse, whilst that in the softer material is almost uniformly fine.

In the Greenbushes field the alluvial deposits may be divided into two main groups, the older being the old river courses or deep leads, and the newer being represented by the existing channels.

In the latter the tin-bearing gravels often lie at from 10 to 40 feet from the present stream bottoms; the older deep leads attain considerable depths, the deepest being 96 feet.

The residual deposits are either lateritic ironstone or sands, clays, etc., derived from the decomposition *in situ*, of igneous rocks. Deposits of this type are frequently stanniferous, the chief minerals accompanying the tin are limonite, quartz, tourmaline, and mica.

Coal-fields.—The Collie Coal-field is the only one upon which any active operations are being carried on, though there are districts in the State in which lignites and brown coals occur.

The Collie Coal-field lies to the east of Bunbury and south of Perth, near the north-western edge of the tableland which succeeds the Coastal Plain. The area occupied by the coal measures is approximately 50 square miles. The strata consist of alternations of shales, sandstones, and grits of Permo-Carboniferous age, which rest directly upon granite, schists, and other crystalline rocks. The boundary of the field is, with one exception, everywhere defined by faults; on the south-western side of the field the boundary fault has been estimated to have a downthrow to the north-east of at least 2,000 feet. There are several coal seams on the field, which are of variable thickness, the greatest being the Wallsend seam, which varies from 9 to 17 feet. According to estimates which have been made, there is, omitting the seams of trifling thickness, about 137 feet of coal in the 2,072 feet of strata so far explored by mining and boring operations. The coal workings are very shallow, and, owing to the comparative freedom of the field from serious tectonic disturbances, difficulties, which would otherwise be involved in working the seams, are not encountered.

The coals of the Collie are hydrous, semi-bituminous, non-caking coals, which approach very closely to lignite in some parts; between the various varieties, however, the differences are only of degree. So far as departmental analyses indicate, it appears that the average calorific value of the Collie coal is about 10,000 British thermal units. The coal is not of such high calorific value as the New South Wales coals, whilst, being non-caking, it crumbles in the furnaces to some extent, and requires a certain amount of increased attention in firing. That from some of the seams has been found rather prone to spontaneous combustion. The Collie coal, although not of the best steam-producing quality, when burned in ordinary boiler furnaces, has been proved to be particularly suitable for use in suction-gas producers.

The coal production of the State up to the end of 1912—which is entirely that of the Collie Coal-field—amounted to 2,323,136 tons, valued at £1,069,435. The principal local consumers are the Government Railways and local manufactories; the gold-fields market for coal is limited, owing to good firewood supplies being available.

6. The Northern Territory.

The Northern Territory comprises an area of 523,620 square miles; of this about 7,400 square miles of mineral-bearing country have been proved to exist in the north-western portion of the Territory, from which the principal products are gold, tin, and copper. These deposits, so far as investigations have at present been carried, are virtually confined to the pre-Cambrian areas lying between the Daly and Mary Rivers.

Since the first discovery of gold in the Northern Territory in 1869, there have been turned out up to the close of 1912, mineral products to the value of £2,843,000, of which gold alone amounted to £2,066,000. The mineral products arranged in the order of value are gold, tin, copper, and wolfram, together with small quantities of tantalite, amblygonite, and bismuth. The mineral production reached its zenith in 1906, when the output was valued

at £146,665; since then there has been a gradual decline, the value of the yield in 1912 being only £57,820.

Enough detailed geological survey work has not yet been carried out to enable many details as to the occurrence and association of the deposits of the mineral fields of the Northern Territory to be definitely set out.

The fundamental rocks of the Northern Territory are of pre-Cambrian age, they cover a very large area, and are of considerable economic importance as they appear, everywhere, to form the matrices of the principal mineral deposits. The pre-Cambrian rocks consist of gneiss, hornblende, and chlorite schist, slate, phyllite, quartzite, and conglomerate, which seem to have been intensely folded, the axes of the folds trending generally north-west and south-east. These ancient sedimentary and allied rocks are invaded by granite (of pre-Cambrian age), which appears to have some genetic connexion with the known tin and wolfram deposits; the beds are also penetrated by basic rocks of various types. Around some of the granite batholiths are broad contact zones of quartz and tourmaline. Veins of quartz and tourmaline, in reality a very acid phase of the granitic magma, extend from the granite into the surrounding schists and very often contain ore of some value. Dykes of pegmatite quartz occur in some localities, *e.g.*, Brock's Creek, and contain large bunches of copper ore. The metamorphic rocks, mica, sericite, talc, and chlorite schist are occasionally traversed by shear zones, trending generally north and south, which often contain mineral lodes of that irregular nature which are characteristic of belts of this particular type. The metamorphic rocks of the McArthur River have been subject to considerable chemical and dynamical alteration, and are traversed by veins containing lead and copper ore, along joint cracks by which the beds are traversed. Igneous rocks are believed to exist at a depth of about 1,000 feet in the McArthur District, and to be responsible for the mineralization of the area.

The tin-fields of the Northern Territory, which, up to the close of 1912, have yielded tin ore valued at £329,000, are scattered over a fairly wide area, the bulk of which is stream tin. In addition to the stream and residual tin, ore has been found in pegmatite granite dykes traversing the slates, schists, and allied metamorphic rocks. The dykes trend generally in a more or less meridional direction, and the ore is disseminated through portions of the mass more or less thickly. The tin-bearing dykes in the West Arm and Bynoe Harbor fields are very numerous. In the Daly River District tin ore has been obtained from a massive tourmaline rock, varying from 50 to 100 feet in width, striking north-north-east. The lode occurs at the junction of quartzose, sandstone, and clay slate, the tin ore occurs in the tourmaline rock in small veins associated with quartz. Slugs of tin ore of considerable weight have been found in the *débris* near the outcrop. At the Horseshoe Creek and Mount Todd Tin-fields there is a considerable area of tin-bearing country. The tin ore in these localities, which occurs as veins and bunches in irregular fissures, traversed the highly inclined sedimentary rocks. The most highly ferruginous rocks are those which have been proved to be the richest in tin.

Small quantities of tantalite and amblygonite occur in the pegmatite dykes of the tin-fields of the Northern Territory, though no great quantity of these valuable minerals has yet been raised.

Wolfram to the value of £40,607 has been mined in the Northern Territory. At Brock's Wolfram Mine, near Wandi, is a deposit remarkable for the size and richness of the ore, which is probably the largest yet found in Australia. The wolfram deposit is a lenticular-shaped mass, containing massive wolfram, scheelite, quartz, and copper pyrites, occurring in a dyke which has a strike of north 20 degrees east, traversing metamorphic sandstones and allied rocks.

A very large proportion of the £2,000,000 worth of gold has been derived from the alluvial and residual deposits which cover a fairly wide extent of country. Gold mining has been carried out in the Darwin Mining District in the north, and in the small fields in the neighbourhood of the MacDonnell Ranges in the southern portion of the Territory.

The Arltunga Gold-field is situated in the southern portion of the Territory, near the MacDonnell Ranges, where the general trend of the auriferous formations is north-west and south-east. The rocks consist of mica, hornblende, and quartz schist, clay slate, limestone, and quartzite, associated with dykes of epidosite, pegmatite, and diorite. The quartz reefs have a general parallelism, coinciding with the strike of the enclosing rocks; the rich shoots of quartz are generally short and the reefs narrow.

The White Range Gold-field in the MacDonnell Ranges was discovered in 1897 in a series of rocks consisting essentially of shattered quartzite, believed to be of pre-Cambrian age. The beds have a low dip of from 10 to 30 degrees. There are, however, no defined lodes, but the auriferous quartz is more or less confined to the fissures and cracks, which traverse the quartzites at all angles and in all directions. When viewed broadly the general trend of the ore bodies is east and west. The White Range field is remarkable for the extraordinary number of its auriferous deposits.

North of Arltunga is the mica field of the Hart Range. The country rock consists of granite and granitic gneiss with basic dykes; the whole being traversed by coarse pegmatite veins and huge masses of pure quartz, which together form the mica-bearing lodes. The mica-bearing dykes, which are numerous and extend over a large area, are extremely irregular both in shape and size. From one of these dykes, near Mount Palmer, a large block of mica, measuring 6 by 5 by 4 feet and weighing nearly 7 cwt., was obtained. Some of these mica-bearing pegmatites, which are believed to be of pre-Cambrian age, contain tourmaline, beryl, and garnets.

7. South Australia.

The State of South Australia is estimated to cover an area of 380,070 square miles.

Since the year 1842, when the first copper mine was discovered at Kapunda, the State has turned out mineral products, the total value of which up to the end of 1912, amounts to £30,427,000. Of this, over £27,000,000 represents the value of the copper as officially recorded.

The principal mineral products of greatest importance in South Australia arranged in order of value, at the end of 1912, are copper (£27,747,000), gold (£921,000), salt, (£815,000), and silver and lead (£338,551).

Copper mining is the most important industry, and the yield of copper far outstrips that of any other single State in the Commonwealth.

The mineral fields of South Australia cover a large area of country, which extends continuously from Kangaroo Island as far north as latitude 30 degrees. Isolated areas are met with in the Musgrave, Mann, and Tomkinson Ranges, in the north-west corner of the State, along the border separating South Australia from the Northern Territory. These areas coincide more or less with those occupied by the metalliferous rocks of Archæan, pre-Cambrian, and Cambrian age. These rocks consist of granite, gneiss, hornblende, mica, and quartz schists, sandstones, conglomerates, and crystalline limestone intersected by granite, diorite, gabbro, porphyry, etc.

So far there does not appear to have been any specially noteworthy zonal arrangement of the mineral deposits detected, which is only possible after an exhaustive and systematic geological survey (now in progress) has been carried out.

Deposits of copper ore are found distributed over a very large portion of the State, though active mining operations, on a serious scale, have been confined to one or two localities.

Yorke's Peninsula, between Spencer's and St. Vincent's Gulf, contain a large area of copper country, which includes the two great mines of Moonta and Wallaroo, which have for over half a century been such a valuable State asset, having produced between them £12,500,000 of copper.

The Wallaroo system of lodes are nearly vertical, having an average strike from 10 to 20 degrees south of east and vary in width from a few inches up to 14 feet. The country rock is micaceous schist, and the ore it contains is chiefly chalcopyrite.

The Moonta Copper lode traverses a quartz-felspar porphyry, the relation of which to the surrounding schistose rocks is not quite clear. The ore channel contains several ore bodies, which vary in width from a few inches up to 20 feet, and have been worked to a depth of over 2,000 feet below the surface. The predominant copper ore is chalcopyrite.

The Blinman Copper lode is another which has been an important producer. The lode is nearly 100 feet in thickness and over 350 feet in length. The ore-bearing belt of strata consist of crystalline siliceous limestone, sandstones, shales, and clay slates, disposed in the form of an anticlinal fold trending north and south intersected by basic and acidic rocks; and it is in the centre of these disturbed strata that the copper lode occurs. The ore is disseminated through the rock in patches, pockets, stringers, and veins, running east and west across the grain of the country forming an ore-bearing belt of from 20 to 30 feet wide. Some of the cross veins are of considerable size, and they are stated to be richer in copper than the main ore-bearing strata they penetrate.

The gold-fields or principal auriferous districts of South Australia are fairly numerous, and cover relatively large areas. The production, however, has not been, in the aggregate, very great, amounting in value to only £921,000 since the inception of active mining operations.

The Barossa Gold-field is made up of rocks believed to be of Lower Silurian age, and consisting of micaceous and hornblende schists, associated with sandstones and slates, and intersected by both basic and acidic dykes. The beds have a uniform strike of north 20 degrees east and an inclination of from 30 to 70 degrees to the east. There are fairly extensive deep leads, believed

to be of Pliocene age; they consist of sand, clay, and gravel, covered by a very ferruginous cement. The payable gold is confined to a layer of from 1 to 2 feet thick lying directly on the bed rock.

In the gold-fields of Talunga and Para Wirra are large areas of older gold-drifts of Tertiary age, now represented by outcrops of cement, sandstone, sand, and gravel, forming nearly all the low hills which flank the range, forming water parting between the Torrens and the Parra River basins. The range is made up of metamorphic rocks, believed to be of Lower Silurian age. These beds are intersected by dykes of granite and pegmatite, which have some genetic relationship with some of the quartz reefs, for some of them (solid white quartz) are seen to pass into granite. The quartz reefs mostly contain large quantities of iron pyrites from which it is probable that the gold is derived.

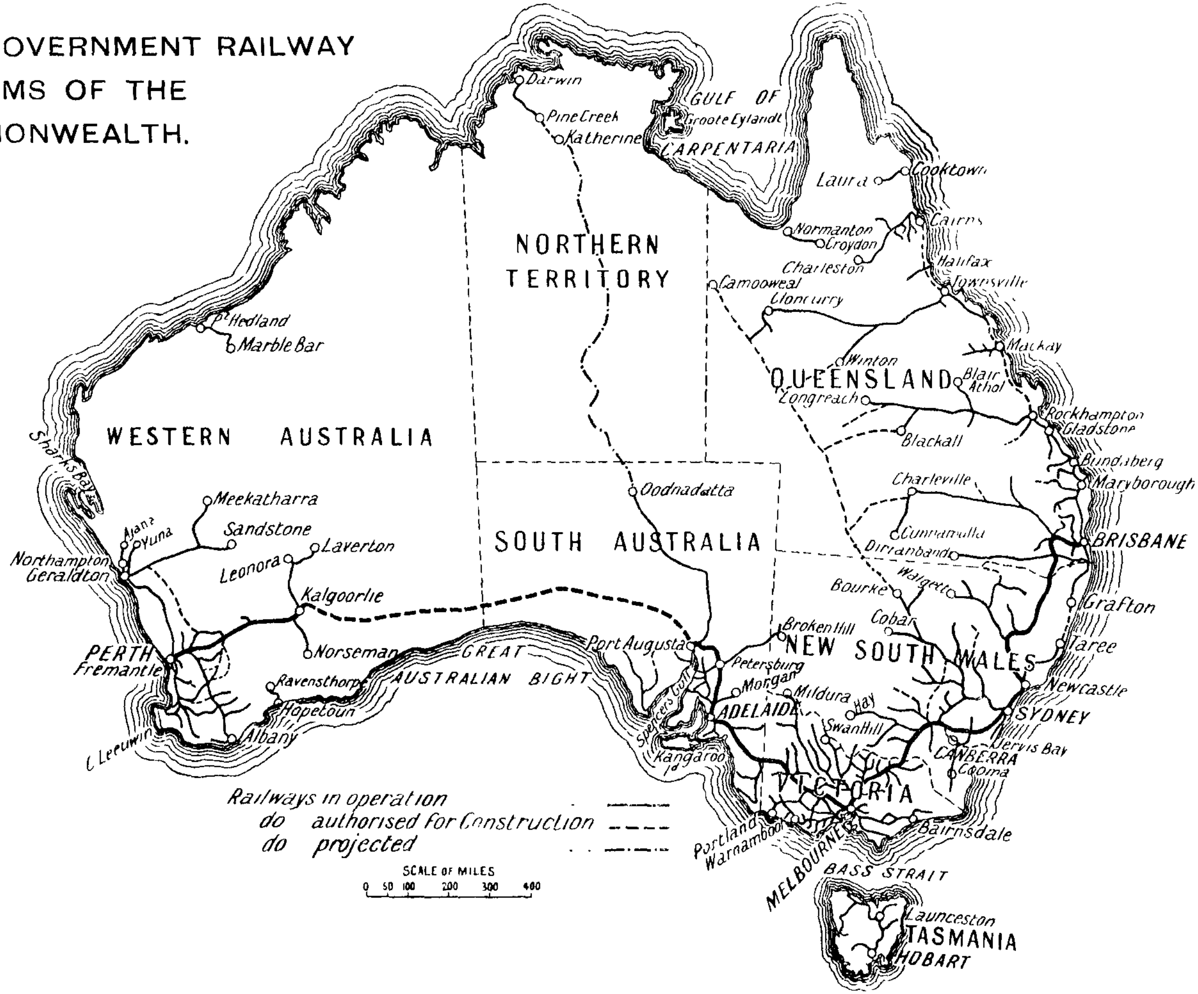
The auriferous portion of the Tarcoola Gold-field extends over an area of about 10 miles in an east and west direction. The rocks enclosing the quartz reefs consist of quartzite, clay slate, and sandstone, resting upon a mica-free granite. The auriferous lodes cross the sediments approximately at right angles to the strike, and cut through them more or less vertically; there are in addition another series of ironstone and quartz lodes, trending approximately at right angles to these, and conformable to the general strike of the sedimentary series and the junction of them and the granite.

Auriferous lodes also traverse the granite and appear to be of the nature of auriferous igneous dykes.

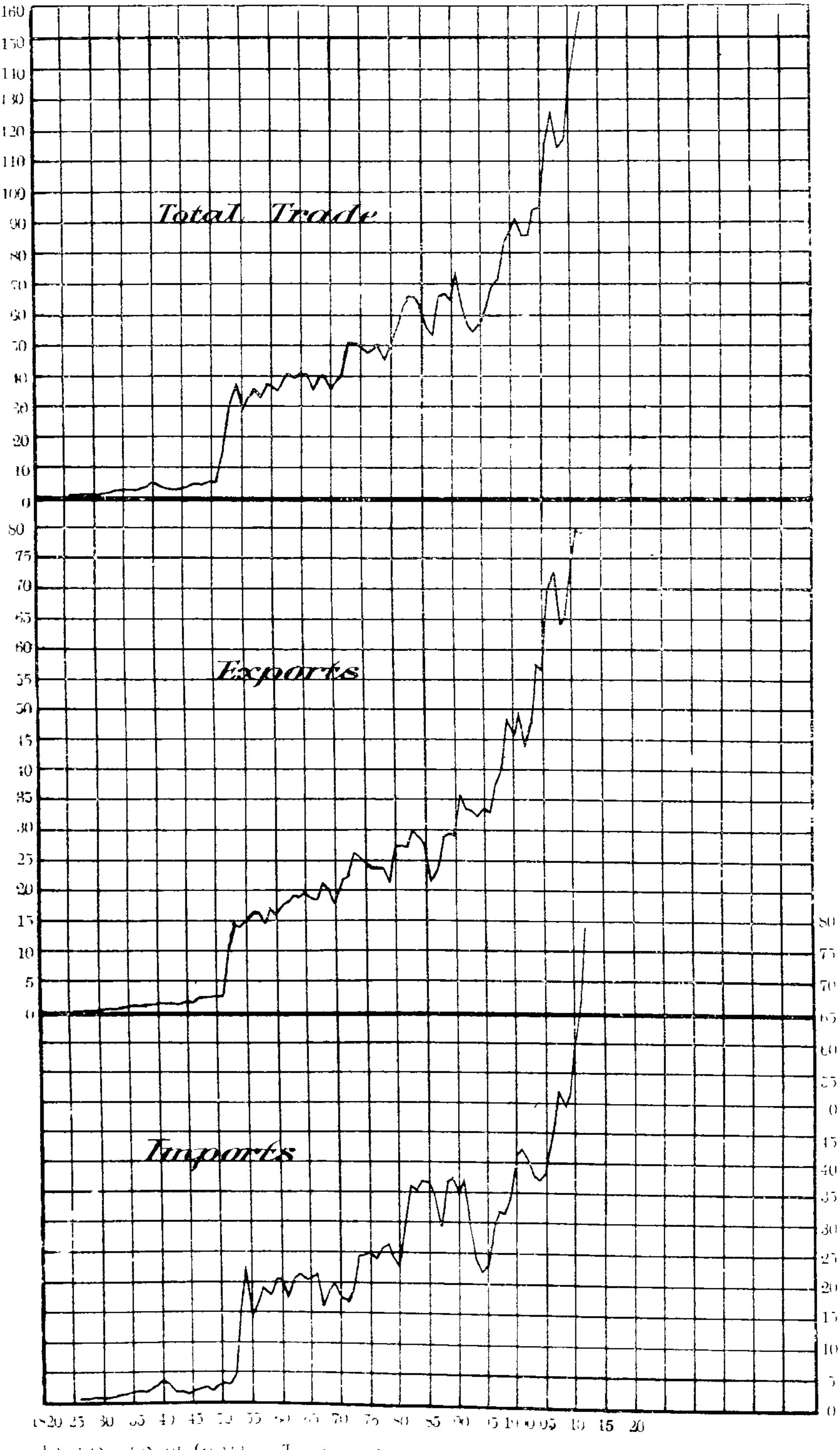
The salt industry of South Australia is of considerable importance, and the principal sources of supply are the salt lakes of the southern portion of the Cape Yorke Peninsula. Small quantities of the rare minerals, corundum beryl, and tourmaline have been met with in different portions of South Australia.

Carnotite, the radio-active mineral, has been mined at Olary, where the ore bodies are pegmatite dykes, believed to be of pre-Cambrian age.

THE GOVERNMENT RAILWAY
SYSTEMS OF THE
COMMONWEALTH.



GRAPHS SHEWING VALUES OF TOTAL TRADE, EXPORTS AND IMPORTS OF COMMONWEALTH 1826 TO 1912



EXPLANATION OF GRAPHS.—The [illegible] represent an interval of five years and the vertical height [illegible] pounds sterling for Imports and Exports, and ten million pounds sterling for Total Trade. The scales for Total Trade and Exports are on the left and that for Imports on the right hand side of the graphs.

CHAPTER XI.

MANUFACTURES, INDUSTRIAL AND COMMERCIAL DEVELOPMENT OF AUSTRALIA.

By Gerald Lightfoot, M.A., Barrister-at-Law.

SYNOPSIS.

1. Historical Survey.

Though Australia cannot yet be considered a manufacturing country, recent years have witnessed a remarkable development in many branches of manufacturing industry, so that the total value of production from that branch of industry is now more than one-quarter of the whole value of the production of the Commonwealth. The estimated value of the total production from all sources has increased from £46,700.000 (or nearly £28 per inhabitant), in 1871, to £188,745.000 (or over £42 per inhabitant) in 1911, and the value of production per inhabitant now exceeds that of any other country for which records are available. The estimated value of the various elements included in the total production in 1911 is as follows :—

ESTIMATED VALUE OF COMMONWEALTH PRODUCTION. 1911.

	£
Agriculture	38,774.000
Pastoral Industry	50,725,000
Dairying, and Poultry Farming ..	19,107.000
Forest and Fisheries	5,728.000
Mining	23.480 000
Manufacturing	50,931,000
Total	£188,745.000

From this it will be seen that the Commonwealth is rapidly becoming an industrial, as well as a pastoral and agricultural, nation. Moreover, the people of Australia, recognising the altered conditions of industrial life and the world-wide change in economic and social conditions, have gone further than other countries in their attempt to regulate the forces which govern the relations between employer and employé. and both Federal and State Parliaments have devised legislation of a novel and interesting type. In this way have arisen the Wages Board and Conciliation and Arbitration Court systems (which will be referred to later), the minimum wage under the Factory Acts and the legalized eight-hours day, the early closing and holiday regulations, and other measures directed to regulate the development of industrial conditions.

Prior to the discovery of gold in 1851 there appeared to be but little prospect of any extensive development of manufactures in Australia, practically the whole of the occupied parts of the continent being given over to pastoral purposes. Agriculture was almost entirely subsidiary to sheep and cattle raising, and was confined to supplying the wants of the small number of persons scattered round the coastal fringe, which then comprised practically the whole of the settled part of the continent. The distance of Australia from the world's markets, the sparseness of its population, and the consequent absence of any considerable local market militated in the early days of settlement against any rapid increase in agriculture, while the progress of the pastoral industry, on the other hand, was facilitated by the ease with which it was carried on, by the suitability of the country, and by the fact that the valuable nature of the products, despite the heavy freightage costs, still left a sufficient margin to compete successfully in the world's markets with other wool-growing countries.

Under these conditions the development of manufacturing industries naturally made but slow progress. The settlements were dependent on outside sources for the supply of the greater part of their food stuffs and for all manufactured commodities, and consequently the comparative isolation of the country gradually resulted in the establishment of factories for the supply of purely local needs.

As late as the year 1848 the number of industrial establishments in Australia did not exceed 479, while the number of persons employed was under 2,000. The most numerous establishments of any one class were flour mills, of which there were in 1848 about 220. The next in number were establishments for the treatment of skins and hides, followed in the order named by breweries and distilleries, soap and candle works, iron foundries, brick works and potteries, and boat building. Of the 479 establishments, 313 were in New South Wales, including 41 in the Port Phillip District (now Victoria), 99 in Tasmania, and 67 in South Australia.* As the average number of employés in these establishments was less than five, it will be understood that many of them were only on a very small scale and would not come within the present statistical definition of a factory in Australia, viz., "any factory, workshop, or mill where four or more persons are employed or power is used."

The principal exports from Australia at this period were wool, tallow, oil, skins, and salt beef, trade being confined almost wholly to the United Kingdom. The quantity of wool exported to that country increased from less than 13 million lbs. in 1841 to nearly 41½ million lbs. in 1850. Whale fishing, although now almost unknown in Australian waters, at one time held an important place among the industries of the country. Whaling stations were established at different places, but by the middle of the nineteenth century the industry was declining in southern waters generally, and Australian shipping came to be engaged more exclusively in the transport trade. In 1850 the value of the exports of sperm oil exceeded £65,000, while the value of tallow exported was £312,000. In the year 1844 copper had been found in South Australia, and in the following year the famous

* In addition there were a few establishments in the Moreton Bay district (now Queensland) and Western Australia, but no information in regard thereto has been recorded.

Burra Burra mine was discovered. By the year 1850 the exports of copper and ore from Adelaide reached over £275,000. The adoption of improved methods of agriculture soon brought about a rapid extension in the cultivation of wheat, and flour soon became an important item of export, especially from South Australia and Tasmania, the total value exported in 1850 exceeding £75,000. The total exports of domestic produce in 1850 from each division of Australia were approximately as follows :—

EXPORT OF DOMESTIC PRODUCE, 1850.

	£
New South Wales (including Moreton Bay District*)	1,159,000
Port Phillip District (now Victoria)	1,022,000
South Australia	571,000
Western Australia	30,000
Tasmania	558,000
Total	£3,340,000

The discovery of gold in large quantities in 1851 completely changed the economic aspect in Australia, and effected a revolution in all industrial relations. As soon as the gold rush set in many of the towns were practically depleted of their male adult population ; and thousands of enterprising men capable of adapting themselves to novel conditions of life, as well as many others, were attracted to the country in the hope of acquiring fortunes. From 1850 to 1855 the population increased from 405,000 to 793,000, that is to say, it was nearly doubled. The eight or nine years during which the gold fever raged exercised an enormous effect on the economic conditions of the working classes ; for had the gold rush not occurred, it is not improbable that, with respect to industrial development as well as to the standards and conditions of living and the rates of remuneration of labour, the conditions existing prior to 1850 would have long remained with but little change. Industrial and commercial development would doubtless have followed in the wake of the pastoral and agricultural industries as time went on, but the opening of the gold-fields had marked effects on the evolution of manufacturing industries in Australia. The first effect of the gold rush was, it is true, disastrous to manufacturing and other industries. The supply of labour in most occupations was exhausted, and many branches of industry came to a standstill. There was, however, a rapid change. Many men, of various trades and occupations, who were drawn to the country by the prospect of rapidly making a fortune, either not meeting with the early success hoped for, or recognising their unfitness for the somewhat strenuous life on the goldfields, decided to settle down in the new country and pursue less precarious, but in many cases more remunerative, callings, while at a later stage the depletion of the richer alluvial deposits, and the consequent decline in the activity of the gold-fields, threw many immigrants, whose early lives had been passed in English cities, out of employment. The surplus of labour thus engendered accumulated in a few of the larger towns in Australia, establishing incipient artisan communities, and this no doubt intensified the early impulses towards industrial employment. The manufactories, therefore, owed their revival and subsequent development

* Now Queensland.

to the population attracted to the country by the gold discoveries. The permanent effect of the latter on the commerce of Australia may be seen in the trade returns. In 1850 the total value of the overseas trade was £5,697,000; by 1860 it had increased to £36,617,000; and thereafter the figures show an almost continuous increase.

The early sixties may be regarded as a transition period in the industrial development of Australia. The country was recovering from the excitement and restlessness of the gold fever, and was settling down to a more prosaic period of sterner conditions and slower, but more stable, growth. The renewal of the attention to agriculture was general, and the acreage under crop rapidly increased, especially in Victoria, which had benefited most by the gold discoveries, and was now the chief financial centre, and, in all other important respects, the leading colony of Australia. During the following years steady progress was made in general development and in agricultural settlement, and the industrial and social conditions now obtaining were gradually evolved. Although there was a considerable fall in the gold returns, there was a steady increase in the quantity of wool and other pastoral produce exported. Victoria held the first place in regard to the value of trade, both of imports and exports, though towards the year 1870 its advantage over the mother State was considerably reduced.

Up to the middle of the nineteenth century free-trade was the established policy throughout Australia. This suited the economic needs of the country, and, though there was nothing in the mere discovery of gold and the consequent rush of immigrants to change the economic motive for a low tariff, a combination of influences, within a decade, due to the gold discoveries, made Victoria adopt a protective tariff. Licence-fees for mining on Crown land and an export duty on gold had been imposed. The former had caused an armed revolt at Ballarat, while the latter made the representatives of the mining districts in the local Parliament favour higher import duties, in order that the export duty on gold might be removed without diminishing the revenues. Both these matters constituted grievances which made the miners hostile to the pastoralist Government then in power and to all its proposals. At the same time the decline in the activity of the gold-fields resulted in the accumulation in a few of the larger towns of a surplus of workers, who were in favour of a protectionist policy and in general sympathy with the miners against what was considered to be a land-holding plutocracy. This led to a severe struggle in commercial, manufacturing, agricultural, pastoral, and political circles, and eventually caused a political crisis. A general election in 1865 resulted in a victory for the protectionists, and in the following year the first Tariff Act of a protective character was passed. The rates of duty were considerably increased in 1877 and afterwards, reaching their highest in 1892. Four years later a few reductions were made, and soon afterwards the local colonial tariff was superseded by the national Commonwealth Customs Act.

While Victoria was pursuing a protectionist policy, New South Wales continued to adhere to free-trade. In 1861 the Government in power in the latter colony was defeated in an attempt to increase the Customs duties in order to meet a deficit in the revenue, but on appeal to the country a Parliament was elected which passed a Tariff Act levying 5 per cent. *ad*

valorem on imports. In 1873 this Tariff was repealed, but ten years later a protectionist party had grown up in New South Wales, and an Act imposing higher duties was passed. The latter Act was repealed by the free-traders in 1887, and from that time several Tariffs were framed, some on free-trade lines, and some providing for slight protectionist duties, until the inauguration of the Commonwealth removed the question from the local Parliament.

It is probable that New South Wales favoured free-trade for the reason that it was thought that Sydney would benefit by being the only large distributing centre in Australia unhampered by Tariff restrictions, and also that, since she possessed the only important coal-fields in the country, protective legislation to encourage the growth of local industries was unnecessary. In these expectations the people of New South Wales were, however, to some extent, disappointed, since Melbourne became for a time the leading financial and industrial centre of Australia. The relatively greater prosperity of Victoria, until the crisis of 1893, was probably the reason for the slow rise of a comparatively mild protectionist party in New South Wales.

In the other colonies the measures adopted in regard to Customs duties were also dissimilar. While some of the Tariffs were manifestly framed on free-trade lines, others indicate clearly the growth of protection and a desire to encourage local manufacture. The Constitution Acts empowered the colonies to impose any duties they saw fit, provided that they were not preferential, even upon imports from England. At various times conferences were held to further inter-colonial trade agreements, but the diverse fiscal policies formed additional obstacles to the framing of any Customs union. At a conference in 1871 it was vainly attempted to establish a commercial union of all the Australian colonies, with proportionate distribution of the Customs revenue, and the British Government was asked to sanction reciprocal conventions to help inter-colonial trade. Two years later another conference demanded "inter-colonial commercial reciprocity," with the result that in 1873 the Australian Colonial Duties Act was passed permitting differential duties among the colonies, but excluding Great Britain from such arrangements. By reason, however, mainly of commercial rivalry, diversity in policy and railway competition, the colonies did not avail themselves of the powers thus conferred, and in the eighties further conventions were held in the hope of forming a Customs union; but it is stated that the opposition of Victoria to entrusting to a commission power to frame a tariff "recognising fairly the interests and special circumstances of each colony" again defeated this project. It was but slowly, therefore, as transport and communication were developed and as intercourse between the colonies became more common, that the people receded from their policy of mutual trade isolation. Finally, with a growth of a spirit of nationality among Australians, the sentiment in favour of Federation made possible a general solution of the inter-colonial Tariff question, together with other problems of union.

2. Commonwealth Commercial and Industrial Legislation.

In addition to the Customs Act providing for the organization and administration of the Federal Customs and the Tariff Acts under which protective rates of duty have been established, a number of other Acts relating to trade and commerce and the regulation of industries have been passed by the

Commonwealth Parliament. Among these may be mentioned the *Sea Carriage of Goods Act* 1904, the *Secret Commissions Act* 1905, the *Commerce (Trade Descriptions) Act* 1905, the *Bounties Act* 1907, the *Manufactures Encouragement Act* 1908, the *Australian Industries Preservation Acts* 1906 to 1910, the *Commonwealth Conciliation and Arbitration Acts* 1904 to 1911, and the *Inter-State Commission Act* 1912.

Probably the most interesting of these Acts are those dealing with what is known as the "new protection," a term which, though novel, is firmly established in Australian economic discussions. It expresses the idea that the protection which the manufacturer receives should be made conditional upon his paying what is considered a fair wage to his employés and providing labour conditions otherwise satisfactory. In the view of those who supported this policy it was considered that the protective tariff might become a shield for trusts and combines, which might reap the benefit of monopoly prices, while keeping the "real" wages of workmen at a low level. The next step was, therefore, to make legislative provision for the repression of monopolies, and the prevention of "dumping," and then to ensure that a protected manufacturer should charge a reasonable price for the products of his factory, and also that the benefits of a protective duty should not be monopolized by the employer, but shared with his workmen. The former of these objects, viz., the repression of monopolies and prevention of "dumping," is attempted in the provisions of the *Australian Industries Preservation Act* 1906 to 1910; the latter, viz., the "new protection," it was sought to attain by means of the *Excise Tariff Act* 1906.

The Industries Preservation Acts have two main objects, viz., (i.) the repression of trusts and other combinations in restraint of trade; and (ii.) the prevention of "dumping." In regard to the former matter the clauses for the repression of monopolies may be summarized thus:—(*a*) Any individual, either as principal or agent, or any company that enters into a contract in restraint of, or with intent to restrain trade or commerce, or to destroy or injure by means of unfair competition any desirable Australian industry, is liable to a penalty of £500. (*b*) Any such person who monopolizes or attempts or combines to monopolize any part of the trade or commerce with other countries or among the States is liable to a similar penalty. (*c*) Any person who, in relation to such trade or commerce, refuses either absolutely or except upon disadvantageous conditions to sell or supply goods or service to any other person for the reason that the latter person deals with others who are not members of a commercial trust is also liable to a penalty of £500. Two attempts to penalize firms, who were supposed to have disregarded the provisions of the original Act had failed, the High Court declaring that certain sections of that Act were *ultra vires*. The main difficulty was that in the prosecution of any offending trader or corporation it was necessary (under the original Act) to *prove* "intent to restrain trade to the detriment of the public." Such proof was found to be almost unattainable, and the amending Act of 1910 provided in effect that the entering into any combination, for what might appear restraint, should be *primâ facie* proof of the intent.

No proceedings have, however, been instituted up to the present time under the Act as amended. In the other part of the Act, which aims at the prevention of "dumping" it is provided that if the Comptroller-General

of Customs has reason to believe that "any person......is importing into Australia goods......with intent to destroy or injure any Australian industry by their sale within the Commonwealth in unfair competition with Australian goods," he can refer the matter to a Justice of the High Court; and if that official, guided "by good conscience and the merits of the case without regard to legal forms and technicalities" decides that the goods are being imported with such intent, their importation shall be prohibited. No proceedings have been taken under this part of the Act, and in spite of the elaborate definitions of "unfair competition" in six subsections of the Act, it would be a difficult task to prove, even in the absence of "legal forms and technicalities," that the intent of the importer was to destroy or injure any Australian industry.

Although the primary object of the Australian Industries Preservation Acts was the restraint of foreign trusts, they apply equally to local trusts within the Commonwealth. By the Customs Tariff 1906, increased duties were imposed upon certain classes of agricultural machinery, notably the "stripper-harvester," a machine invented in Australia, which has, to a great extent, replaced the "reaper and binder and thrashing machine" in the harvesting of wheat. By the same Act it was declared that the machines scheduled should not be sold at a higher cash price than was thereby fixed, and that if that price should be exceeded, the Commonwealth Executive should have power, by reducing the Customs duties imposed by the Act, to withdraw the Tariff protection.

By another Act of the same year (the *Excise Tariff Act* 1906) an excise of one-half the duty payable upon imported agricultural machinery was imposed upon similar machinery manufactured in Australia. But it was declared that the latter should be exempt from excise if the manufacturer thereof complied with the following provision, namely, that the goods be manufactured under such conditions as might be declared by resolution of both Houses of Parliament to be fair and reasonable, or as might be approved by the President of the Commonwealth Arbitration Court. Another Act carried into effect similar provisions in regard to distilleries, and it was proposed to apply the system of removable excise duties to a large number of other protected industries.

In Victoria, "this whole controversial problem with its grave social and economic bearings" (to quote the words of the President of the Court) was discussed in a lengthy case upon the application for exemption by Victorian manufacturers, now widely known as the "Harvester Case," and in the report of that case may be found the legal interpretation of the Acts under consideration. The exemptions claimed were refused, and the court after discussing the meaning of the words "fair and reasonable" defined them by laying down what it considered to be a scale of fair and reasonable wages.

The High Court has pronounced that the legislation under these Excise Acts is unconstitutional as being an extension of Federal action beyond the powers granted, and a usurpation of the powers reserved to the States. It may be noted that the rejected measures were enacted with the consent of all parties in Parliament, having been placed upon the Statute Book whilst the Liberal party was in power, the Labour representatives strongly supporting the proposals. This legislation, although now ineffective, remains on the Statute Book as the pioneer effort of any Parliament to apportion

the benefits of a protective system between employers and employed, and to prevent advantage being taken of the Tariff to raise prices unduly.

The provisions of these and the Arbitration and Wages Board Acts may be regarded as indicating the general trend of a large body of opinion in Australia in regard to the State regulation of private enterprise. While there is a considerable section of socialistic thought which aims at the progressive extension of the sphere of public ownership, the more conservative element advocates the development of legal and administrative control. In view, however, of the limitations of the Federal Constitution Act and of the world-wide concentration of capitalism and development of monopolies and trusts, the socialist reformer is faced with the necessity of dealing with the question of the public regulation of private industries on lines which are immediately practicable. Hence both parties are interested in the development of legislation on the lines indicated. While the field of Commonwealth regulation of trade, commerce, and industrial matters is limited by the Constitution Act, the exercise of the functions of the Commonwealth in this direction has suffered from the absence of any administrative body entrusted with adequate powers of investigation and control. This need, *inter alia*, the Inter-State Commission is designed to supply.

This body, which was appointed in August, 1913, is constituted as a Court of Record in the exercise of its judicial powers of adjudication, and is empowered to investigate matters affecting production, trade, industries, manufactures, external markets, tariffs, prices, profits, wages, industrial conditions, foreign shipping, or export bounties, river questions and other matters referred by Parliament. The Commission may act either on the complaint of any individual or on its own initiative. It may grant such relief as it deems proper, award damages, issue injunctions, fix penalties, and prescribe future action as by naming a maximum or minimum rate for certain services. It is also vested with extensive powers in regard to the regulation of Inter-State commerce. No appeal lies from the Commission, except to the High Court on questions of law. It may thus be seen that the powers and functions of the Commission are both extensive and important. The Commission is now engaged as a tariff board and is investigating the need for, and incidence of, protective duties. It is stated that it was the intention of the Labour party, by whom the Act creating the Commission was passed, that it should be used to make inquiries regarding industries alleged to be the subject of monopolies or combines, with a view either to the nationalization of such industries or to fixing the prices to be charged for the commodities produced. The work and operations of the Commission will be watched with interest, since time alone can prove the value of what must now be regarded as an economic and social experiment.

By the *Commerce (Trade Descriptions) Act* 1905, power is given to compel the placing of a proper description on packages of imports or exports of certain prescribed goods. The operation of the Act is restricted to the following classes of goods :—(*a*) Articles used for food or drink by man, or used in the manufacture or preparation of articles used for food or drink by man ; or (*b*) medicines or medicinal preparations for internal or external use ; or (*c*) manures ; or (*d*) apparel (including boots and shoes), and the materials from which such apparel is manufactured ; or (*e*) jewellery ; or (*f*) seeds and plants.

The *Bounties Act* 1907, the *Manufactures Encouragement Act* 1908, and the *Shale Oil Bounties Act* 1910 make provision for the encouragement of certain Australian industries by the payment to producers of moneys allotted by the Acts upon the production of the commodities specified. The Acts also provide for the refusal or reduction of a bounty, if the production of a commodity is not accompanied by the payment to the workers employed in that production of a fair and reasonable rate of wage. Reference to the Commonwealth Conciliation and Arbitration Act is made in a later part of this article.

3. Legislative Regulation of Wages and Conditions of Labour.

(a) Wages Boards and Arbitration Courts.

Two systems, based upon different principles, have been adopted in Australia for the regulation of wages and general terms of contracts of employment. A "Wages Board" system exists in Victoria and Tasmania, and an Industrial Arbitration Court in Western Australia. In New South Wales, Queensland, and South Australia combinations of the two systems have now been evolved, Industrial or Wages Boards, as well as Industrial Courts, being instituted. There is also the Arbitration Court of the Commonwealth, which has power, however, to deal only with disputes extending beyond the limits of a single State.

The fundamental difference in principle between the Wages Board and the Arbitration Court systems is that the Wages Board, once established, itself takes the initiative, and immediately sets to work, without waiting for a dispute, to frame wages and conditions of employment for the trade under review, whereas under the Arbitration Court system a tribunal cannot itself initiate proceedings, but must wait until a dispute comes within its official cognisance. Under the Wages Board system, moreover, each trade or industry has its own Board, whereas a single Arbitration Court would ordinarily deal with all trades within a district. Another important difference lies in the nature of the tribunals, the Wages Board consisting of persons representing the employers and employés respectively, with a nominated or independent chairman, while the Arbitration Court consists of one member only—a Judge of the Supreme or High Court—who may, however, be assisted by assessors. Again, it may be observed that under the Arbitration Court system, anything in the nature of a strike or lock-out is expressly forbidden under penalty, provision being made for conciliation in matters under dispute by reference to the Court, by means of compulsory conferences and by the registration of industrial agreements. No provisions for the settlement of disputes exist under the Wages Board system.* It should

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* In the Tasmanian Act, however, clauses have been inserted making it a penal offence to take part, or assist, in a strike or lock-out.

† Information regarding the history and working of various Acts in Australia providing for the legislative regulation of wages, etc., may be found in the following reports:—Report of Royal Commission on Working of Compulsory Conciliation and Arbitration Laws, 1901 (Sydney, Government Printer); Report of Royal Commission on Factories and Shops Law in Victoria, 1902–3 (Melbourne, Government Printer); Report to Secretary of State for the Home Department on the Wages Boards and Industrial Conciliation and Arbitration Acts of Australia and New Zealand, by Ernest Aves, 1908 (London, Darling and Son, Cd. 4167); Strikes and Lock-outs—Memoranda by Board of Trade, 1912 (London, Darling and Son, Cd. 6081); Interim and Final Reports of the Royal Commission on Industrial Arbitration in New South Wales, 1913; The New South Wales Industrial Gazette (Sydney, Government Printer); The Industrial Arbitration Reports and Records, New South Wales (Sydney, Government Printer); Victoria, Annual Reports of Chief Inspector of Factories, Workrooms, and Shops (Melbourne, Government Printer); Queensland, Annual Reports of the Director of Labour and Chief Inspector of Factories and Shops (Brisbane, Government Printer); South Australia, Annual Reports of Chief Inspectors of Factories (Adelaide, Government Printer); Western Australia, Annual Reports of Proceedings under the Industrial Conciliation and Arbitration Act, and Reports of Proceedings before the Boards of Conciliation and Court of Arbitration (Perth, Government Printer); Tasmania, Reports of the Chief Inspector of Factories (Hobart, Government Printer); Commonwealth Arbitration Reports, Vols. I. to V. (Melbourne, Government Printer).

be observed, however, that although the Arbitration Court attacks the problem at the other end, aiming primarily at the prevention of strikes, the chief work of the Court is not, perhaps, so much concerned with the maintenance of industrial peace as with the settlement of certain definite minimum conditions of employment.

The Wages Board system was introduced in Victoria by the Factories and Shops Act of 1896.† The original Bill applied to three industries only (viz., the clothing, furniture, and breadmaking or baking trades), in which conditions of labour were notoriously bad and sweating prevalent. The effect of these Boards in improving conditions of labour soon became apparent, and the scope of the Act was consequently extended in 1900, and again in 1907, 1910, and 1912, and at the present time a Wages Board can be appointed for any process, trade, business, or occupation in the State. A Court of Industrial Appeals, consisting of a Supreme Court Judge, with power to call in two assessors, has been established to act as a Court of Appeal from the determinations of Wages Boards Twelve appeals have been heard and in ten of these the decisions of the Boards were varied. Up to the end of August, 1913, no fewer than 131 Boards had been authorized, the determinations gazetted affecting upwards of 150,000 persons.

In Victoria a Wages Board is appointed on resolution by both Houses of Parliament, one-half of the members being representatives of employers and one-half of employés. The names of members are first submitted by persons interested, and then appointed by the Governor in Council on the nomination of the Minister. The chairman is nominated by the members, but if they do not agree to a chairman, he is appointed by the Governor in Council on the recommendation of the Minister. The times of meeting, the mode of carrying on business, and all procedure are entirely in the hands of the Board, whose powers are defined in the Factories Acts. The result of the labours of a Board is called a "Determination," and each item of such determination must be carried by a majority of the Board The chairman is a member of the Board. His function is usually confined to conducting the proceedings. He does not exercise his vote except in cases where the Board is equally divided, when his casting vote determines the question at issue. When a determination has been finally made, it must be signed by the chairman, and forwarded to the Minister of Labour. The Board fixes a date on which the determination should come into force, but this date cannot be within 30 days of the date upon which a price or rate of pay was last fixed. If the Minister is satisfied that the determination is in form, and can be enforced, it is duly gazetted. In the event of the Minister considering that any determination may cause injury to trade, or injustice in any way whatever, he may suspend same for any period, not exceeding six months, and the Board is then required to reconsider the determination. If the Board does not make any alteration, and is satisfied that the fears are groundless, the suspension may be removed by notice in the *Gazette*. Provision is made by which either employers or employés may appeal to the Court of Industrial Appeals against any determination of a Board. An appeal may be lodged (*a*) by a majority of the representatives of the employers on the Special Board; (*b*) a majority of the representatives of employés on the Special Board; (*c*) any employer or group of employers, who employ not less than 25 per cent. of the total number of

† See Note on page 471.

workers in the trade to be affected; or, (*d*) 25 per cent. of the workers in any trade. The Court has all the powers of a Board, and may alter or amend the determination in any way it thinks fit. The decision of the Court is final and cannot be altered by the Board, except with the permission of the Court, but the Court may, at any time, review its own decision. The Minister has power to refer any determination of a Board to the Court for its consideration, if he thinks fit, without appeal by either employer or employé. The decision of the Court is gazetted in the same way as the determination of the Board, and comes into force at any date the Court may fix. The determinations of the Board and the Court are enforced by the Factories and Shops Department, and severe penalties are provided for breaches of determinations. No prosecution for any offence against any of the Factories Acts, or for any breach of any determination can be brought except through the Department.

In Tasmania a Wages Board system was introduced by the *Wages Board Act* 1910. Amicable settlement of disputes and the adjustment of relations between employers and employés, more especially in regard to wages, was speedily shown to be a forlorn hope owing to the retention of what is known as the "reputable employers" clause. This limited the wages to be determined by a Board to those paid at the time the Board was established. It was pointed out that this provision had been repealed in Victoria in 1907, and in view of the strenuous opposition of the employés to its retention in Tasmania, an amending Act was passed in 1911 repealing the clause. The appointment of twenty Boards has been authorized, and of these fifteen have made determinations. In its general features the system in operation in Tasmania closely resembles that of Victoria, but in the former State it is a penal offence to take part or assist in a strike or lock-out on account of any matter in respect of which a Board has made a determination.

Since it is not practicable to furnish within the limits of this article any comprehensive description of the systems in force in each State, a tabular statement showing some of the more important features of the Acts is given on pages 474 and 475.

In New South Wales the Acts in force during the first period during which legislative intervention in industrial disputes was attempted, viz., the *Trades Disputes Conciliation and Arbitration Act* 1892, and the *Conciliation and Arbitration Act* 1899, were based on the idea that voluntary conciliation would be the most effective instrument in the adjustment of grievances. As neither of these Acts compelled either party to a dispute to submit its case, they both proved ineffective. In 1901 the Arbitration Court system was adopted in the Industrial Arbitration Act of that year. This Act provided for the registration of industrial unions and for the making and enforcing of industrial agreements. A Court of Arbitration was constituted for the hearing and determination of industrial disputes and matters referred to it, and the jurisdiction, powers, and procedure of that Court were defined.

TRIBUNALS FOR THE REGULATION OF WAGES

Particulars	New South Wales.	Victoria.	Queensland
Name of Acts ..	*Industrial Arbitration Act* 1912	*Factories and Shops Act* 1912	*Industrial Peace Act* 1912
Nature of Tribunals	Court of Industrial Arbitration Industrial Boards	Court of Industrial Appeals. Wages Boards	Industrial Court Industrial Boards
How Tribunals are brought into existence	Industrial Court (Judge) constituted by Act. Industrial Boards by the Minister on recommendation of Industrial Court	Court constituted by Acts Wages Boards by Governor in Council on resolution of Parliament	Industrial Court constituted by the Act Industrial Boards by Governor in Council on recommendation of Court
Scope of Acts ..	To industrial groups named in Schedule to Act, and those added by Proclamation. Includes Government servants	To any process, trade, business, or occupation specified in a resolution. Government servants are not included	To callings specified in Schedule to Act, and to those added by Governor in Council
How a trade is brought under review	Reference by Court or Minister, or by application to the Board by employers or employes	Usually by petition to Minister	By petitions and representations to Industrial Registrar
President or Chairman of Tribunal	Appointed by Minister on recommendation of Court	Appointed by Governor in Council on nomination of Board or failing that on nomination by Minister	Any person elected by Board. If none elected, appointment is by the Governor in Council on recommendation of Court
No. of members of Tribunal	Chairman and two or four other members	Not exceeding eleven (including chairman)	Not less than five nor more than thirteen (including chairman)
How ordinary members are appointed	Appointed by Minister on recommendation of Industrial Court	Nominated by Minister But if one-fifth of employers or employés object, representatives are elected by them	By employers and employes respectively
Decisions — How enforced	By Registrar, Industrial Magistrate and Inspectors	By Factories Department in Courts of Petty Sessions	By Inspectors of Factories and Shops, Department of Labour
Duration of decision	For period fixed by Tribunal, but not more than three years	Until altered by Board or Court of Industrial Appeals	Twelve months and thereafter, until altered by Board or Court
Appeal against decision	To Industrial Court against decision of Boards	To the Court of Industrial Appeals	To Industrial Court ..
If suspension of decision possible pending appeal	No . . .	Yes; for not more than twelve months	Yes; for not more than three months
Can preference to unionists be declared	Yes ..	No	No
Provision against strikes and lock-outs	Strikes, penalty £50, and preference to unionists cancelled Lock-outs, penalty £1,000	None . .	Strikes association £1,000; individual £50 lock-outs £1,000, unless notice of intention given to Registrar and secret ballot taken in favour In the case of public utilities compulsory Conference also must have proved abortive
Special provisions for Conciliation	Special commissioner Three Conciliation Committees for colliery districts. Registered agreements	None .. .	Compulsory Conference Registered agreements

* The operation of the Commonwealth Act is limited by the Constitution to conciliation and arbitration

IN TRADES IN AUSTRALIA, 1913.

South Australia.	Western Australia.	Tasmania.	Commonwealth.*
The Factories Acts 1907, 1908, and 1910. *Industrial Arbitration Act* 1912	*Industrial Arbitration Act* 1912	Wages Boards Acts 1910 and 1911	*Conciliation and Arbitration Act* 1904–11
Industrial Court. Wages Boards	Arbitration Court ..	Wages Boards ..	Court of Conciliation and Arbitration
Court constituted by Act of 1912. Wages Boards by the Governor in Council	Constituted by the Act..	For the clothing trade, by the Act; for other trades, by a resolution of Parliament	Court constituted by the Act
To processes, trades etc., specified in Act, and such others as may be authorized by Parliament	All industrial occupations	All trades, or groups or parts thereof	Industrial disputes extending beyond limits of any one State or in Federal Capital or Northern Territories
Court—matters or disputes submitted by Minister, Registrar, employers, or employés, or by report of Wages Board. Wages Boards by petitions, etc.	Industrial disputes referred by President or by an Industrial Union or Association	By application of parties	Industrial disputes either certified by Registrar, submitted by organization, referred by a State Industrial authority or by President after holding abortive Compulsory Conference
Court—President. Wages Board, appointed by Governor on nomination of Board, or failing nomination a Stipendiary Magistrate	A Judge of the Supreme Court	Any person elected by the Board. If none elected, appointment by the Governor in Council	President
Court. President only. Wages Board, not less than five nor more than eleven (inclusive of chairman)	Three, including president	Chairman, and not less than four nor more than ten	President only
By Governor on nomination of employers and employes respectively	Appointed by Governor, President directly, and one each on recommendation of unions of employers and workers respectively	By Governor in Council on nomination by employers and employes	President appointed by Governor-General from Justices of High Court
By Factories Department	By Arbitration Court on complaint of any party to the award or Registrar or an Industrial Inspector	By Factories Department	By proceedings instituted by Registrar, or by any organization affected, or a member thereof
Until altered by Board or by order of Industrial Court	For period fixed by Court, not exceeding three years, or for one year and thenceforward from year to year until 30 days' notice given	Until altered by Board	For period fixed by award not exceeding five years
Industrial Court ..	No appeal except against imprisonment or a fine exceeding £20	To Supreme Court..	No appeal. Case may be stated by President for opinion of High Court
Yes	No suspension. Court has power to revise an award after the expiration of twelve months from its date	Yes	No appeal
No	No	No	Yes; ordinarily optional, but mandatory if in opinion of Court preference is necessary for maintenance of industrial peace or welfare of society
Penalty £500, or imprisonment three months	Employer or Industrial Union, £100; other cases, £10	Organization £500; individual £20	Penalty, £1,000
Compulsory Conference. Industrial Court. Registered agreements	Compulsory Conference. Registered agreements	None ..	Compulsory Conference. Court may temporarily refer to Conciliation Committee. Registered agreements

for the prevention and settlement of industrial disputes extending beyond the limits of any one State.

This Act abandoned the principle of conciliation in favour of arbitration, the jurisdiction of the Court extending to all industries except domestic service, and its awards applying without limitation of area throughout the State. Provision was also made for the registration of industrial agreements. This Act, however, proved unsatisfactory, mainly for the reasons that the congestion of business in the Court culminated in industrial unrest and that the High Court decided that the Court had no jurisdiction to declare the terms of an agreement to be a "common rule," in other words an employer on entering into an industrial agreement might bind himself for a specified time to pay higher wages than those paid by other employers in the same industry.

In the *Industrial Disputes Act* 1908 an effort was made to combine the relatively simple procedure of Conciliation Boards with the compulsory powers of the Arbitration Court as to enforcement of findings and awards. The Boards had power to decide all disputes and to rescind or vary any of their awards, and in carrying out these purposes they were empowered to fix minimum wages and other conditions of labour. The Board system established by this Act was responsible for the effective operation of some 230 Boards and the making of 430 awards. The multiplicity of Boards under this Act was, however, the cause of considerable overlapping of awards and consequent confusion. It was mainly the difficulties arising from this confusion which led to a reconsideration of the whole scheme and to the passing of the *Industrial Arbitration Act* 1912, now in force. Under this Act it was intended there should eventually be about 150 Boards presided over by 28 chairmen, one for each group of industries, and each having jurisdiction in a clearly defined industrial area. In addition a Court of Industrial Arbitration was established and provision was made for the constitution in certain mining districts of Conciliation Committees. The organization of the Boards under the new Act is based on the principle of craft unionism, *i.e.*, all craftsmen in each trade, such as carpenters, engine-drivers, painters, and so on, belong to the same union, and are dealt with by the same Board. These Boards are judicial tribunals and not round-table conferences, their powers being wider than those of ordinary wages boards, and extending to the determination of any "industrial matter" and to the granting of preference of employment to unionists.

In Queensland, the Wages Boards Acts were repealed in 1912, and replaced by the Industrial Peace Act, which contains provisions for the establishment of industrial boards and of an Industrial Court, which has both original and appellate jurisdiction. In South Australia a combination of the two systems has also been evolved by the *Factories Act* 1907–1910 and the *Industrial Arbitration Act* 1912. In the former State, however, the industrial boards have wide powers to determine any industrial matter or dispute, while in South Australia the powers of the boards are generally similar to those of the wages boards in Victoria and Tasmania, the Industrial Court only having power to adjudicate upon industrial disputes. In both States severe penalties are provided against strikes and lock-outs, while in South Australia "picketing" is also prohibited under penalty. In the latter State refusal to offer or accept employment upon the terms of an industrial agreement or award is deemed to be a lock-out or strike.

Western Australia is the only State in which the Arbitration Court system by itself is still in existence. This system, which is also in force under the *Commonwealth Conciliation and Arbitration Act* 1904–1911, is framed to encourage a system of collective bargaining, to facilitate applications to the Court for the prevention of disputes, and assure to the worker such benefits as may be derived from organization. It virtually creates the industrial union, which is not necessarily identical with the trade union, but rather an organization necessary for the administration of the law. As in New South Wales, Queensland, and South Australia, so under the Commonwealth and Western Australian Acts employers and employés may settle disputes and conditions of labour by industrial agreements, which are registered and have the force of awards. Failing agreement, disputes are settled by reference to the Court.

As regards the effects of operations under these laws, dispassionate observers are generally inclined to believe that the systems of regulating wages and hours of labour have in the main been successful. Investigations made by the Commonwealth Statistician show that between 1901 and 1912 *nominal* wages increased on the average by no less than 24 per cent., and though it is true that the increase between these two years was more than discounted by the increase in cost of living, this was due largely to the phenomenal rise in prices and rents which occurred in 1912. Thus between 1901 and 1911 *effective* wages increased by nearly 4 per cent., but between 1901 and 1912 they decreased by about 1 per cent. While it is true that prices and cost of living have not increased in Australia to a greater extent than in many other countries, one of the factors which *tend* to increase prices, viz., increase in wages by industrial tribunals, is prevalent to a far greater extent in Australia than elsewhere. And though it is not, of course, suggested that an increase in wages necessarily results in increased prices, in many industries the employers have been able through trade associations and by other means to pass on to consumers a considerable proportion of the increased amount of their wages bills. Hence many of the workers, having succeeded in obtaining machinery for the regulation of "nominal" wages, are now desirous of extending legislative effort so as to control "effective" or "real" wages. The proposals for carrying this idea into effect (either by the nationalization of industries subject to operations of monopolies or combines or by fixing prices) do not, however, fall within the scope of this paper.

While statistics show, therefore, that there has been a large increase in nominal wages, it is equally clear that this increase has been so far effected without, on the aggregate, unduly taxing the resources and industries of the country. This is shown in various ways by the extension of manufacturing industries, by the increasing prosperity of the people, by the large rise in savings bank deposits, by the railway and tramway receipts, and by the increased consumption of commodities of the nature of luxuries.* Furthermore, statistics indicate that the relative productive efficiency of labour has increased in recent years,† but whether this be due to the human element

* See *Official Year-Book of the Commonwealth of Australia*, No. 6, 1912, by G. H. Knibbs, C.M.G., &c.
† See Report No. 2—Labour and Industrial Branch of the Commonwealth Bureau of Census and Statistics, by G. H. Knibbs, C.M.G., &c., p. 69. Taking the relative productive activity for all industries in 1901 as base (= 1,000), the increase in 1908 was 13·7 per cent., and in 1911, 35·5 per cent.

or to improved organization and machinery, or to both these factors, is not revealed by the figures available. The fact that the productive activity and efficiency in manufacturing industries has increased is borne out by an analysis of the manufacturing statistics. Thus while the percentage of wages paid on the total value of the output of manufacturing industries increased between 1908 and 1912 from 19·8 to 21·0 per cent.* the percentage available for interest, depreciation, other charges, and profit also increased uniformly from 16·5 in 1908 to 17·9 in 1911, though it decreased slightly (to 17·2) in the following year, showing that in spite of the increased wages the percentage available for interest, depreciation, profits, etc., had increased. Available evidence indicates, therefore, that the effect of the legislative control of wages and conditions of labour has been of benefit both to wage-earners and employers, and that the evil effects predicted have not come to pass. The complexity of the factors which operate, both those which are purely local and others which are traceable to a wider and even world-wide range of influences, render the appraisement of the effects of the Acts a matter of difficulty. This difficulty would exist even if the Acts had been in force for long periods. In some of the States they have, however, been in operation for only short periods, so that even the purely economic influences have not been fully revealed, while their social and moral aspects remain hidden. Rapid changes have occurred in the class of legislation under consideration, and have been facilitated by the comparative simplicity of industrial organization as compared with older communities, by the small populations of the States, and by the democratic sympathies of the people. Although the attitude of public opinion might be one of the best guides in judging the efficiency of the respective Acts and systems in force, beyond the fact that there is a widespread determination to adhere to the principle of the minimum wage, at any rate for the present, there is no united opinion, or even a united class opinion, concerning the relative advantages or efficiency of the various Acts. On the contrary, the ebb and flow of opinion, and even sectional cleavage in attitude, has been marked. Criticism is, however, directed at the details of the systems or at the administration of the Acts, rather than at the class of legislation as a whole. The numerous amending Acts, consequent on weaknesses which have been disclosed, indicate the fluidity of opinion which exists, and have strengthened rather than weakened the determination to adhere to the legal minimum wage. A great deal of the success of the systems lies, no doubt, in the prosperity which has been enjoyed in recent years owing largely to the preponderating effect of favorable seasons on the important primary industries. Wages have almost invariably been increased and the Acts have consequently worked smoothly so far as the wage-earners are concerned. It is possible, however, that this tranquillity will not be long maintained. It is thought by some that the time is approaching when the social conscience of the people will be satisfied and that the workers will reach the point of diminishing returns in State regulation. In conclusion it may be said that more accurate knowledge and more profound study than have yet been devoted to the subject will be required to furnish definite conclusions as to the economic and social results of these industrial laws, and as to the relative merits and demerits of the various systems.

* See Labour Bulletin, No. 3, November, 1913, by G. H. Knibbs, C.M.G

(b) Factory and Shop Acts.

The State Factories Acts do not differ in principle from those in force in the United Kingdom, the general object of this class of legislation being to fix minimum standard rates of wages and maximum hours of labour, to provide for sanitary accommodation, the ventilation and cleansing of premises, safeguarding from accident, and the general amelioration of the conditions of labour, particularly those of females and children, in factories.

The first Australian Factories Act was passed in 1873 in Victoria. It was entitled "The Supervision of Workrooms and Factories Statute," and contained only six sections. Its principal provisions were (*a*) that any place in which not less than ten persons were engaged for hire in manufacturing goods should be constituted a factory; (*b*) that such factories, as to building, sanitation, etc., should be subject to regulations made by the Central Board of Health; and (*c*) that no female should be employed for more than eight hours in any one day without the permission of the Chief Secretary. The administration of the Act was entrusted entirely to the local Boards of Health, and the system was found to be less effective than was hoped. The conditions which have given rise to trouble in the old world tended to reproduce themselves in the young and growing industries of the States. Factory workers had to contend with the absence of security for a living wage, unsatisfactory sanitary surroundings, and unchecked and unscrupulous competition of Chinese in certain trades. The advocacy of legislation to control the conditions of employment became pronounced in Victoria in 1880, and a strike of tailoresses in Melbourne in 1882 led to a recognition of the real state of affairs. As a result of unsatisfactory working under the local governing bodies, and on account of agitation of the operatives, a commission was appointed in 1883, and reported the necessity of legislation for the regulation of factories, and in particular pointed out the fact that men were compelled to toil for as many as eighteen hours and women sixteen hours a day. It also showed that the condition of out-workers was very undesirable, and that the apprenticeship system was frequently used to obtain labour without remuneration, apprentices being dismissed upon asking for payment at the end of their time. The *Factories and Shops Act* 1884, while providing for the suppression of many evils in respect of accommodation and lengthy hours, did not touch the two last mentioned. It provided for Government inspection, and also that six persons should constitute a factory if the premises were situated in a city, town, or borough. In 1887 a short amending Act was brought in to remedy some defects that were found to exist. Its principal provision was that any place in which two or more Chinese were engaged should be deemed a factory. In 1893 a further enactment reduced the number of persons constituting a factory to four. Another Royal Commission sat in 1895, resulting in the Act of 1896, which dealt with matters previously untouched, and the system of regulation was carried on by the Act of 1900 and the complete codification of the law in 1905, and again in 1912.

Similar conditions to those which existed in Victoria were found to prevail in other States. New South Wales and Queensland first adopted regulative measures in 1896, South Australia in 1894, and Western Australia in 1902. Tasmania adopted the Victorian Act of 1873 in 1884. The same remarks apply in a general way to the condition of employés in shops.

The adoption of the eight hours system for adult males has generally been the outcome of the representations made by the trade unions. There is no legislation to enforce the principle, although there is now a general recognition of it. A week of 48 hours is the usual working week. The larger unions, however, have lately moved for a *net* day of eight hours, with Saturday half-holiday, no loading of other week days being permitted by way of compensating for the Saturday afternoon. Under this scheme there are, for five days, equal divisions for periods of labour, recreation, and rest, and four hours' work on Saturday, making a working week of 44 hours. On the establishment of Wages Boards and Arbitration Courts, in the States where those institutions exist, the authorities thus created generally adopted the principle of 48 hours a week as part of their determinations and awards wherever it seemed reasonably practicable. In some of the larger classes of building trades the hours have been reduced to 44 a week, and in some technical and specialist trades a lower maximum has been fixed, such for example, as the type-setting machine operators in Victoria, for whom the maximum has been fixed by the Wages Board at 42 hours weekly. Reasonable provision is made by statute or award for work performed outside the scheduled hours. Organizations of employés, however, oppose overtime in any industry until all the operatives in that industry are working full time.

In all the States the employment of female labour in factories is now regulated by Act of Parliament. The number of working hours is limited to 48 per week, overtime being allowed only with the permission of the Factory Departments, and even then to a limited extent only. The maximum periods of continuous labour and the intervals of cessation therefrom are all prescribed under the several Acts.

The employment of young persons in factories is also regulated in each State by Acts of Parliament in a similar manner to the employment of female labour. Excepting under special circumstances, children under a certain age may not be employed in factories. The minimum age in all the States is fourteen, with the exception of South Australia, where it is thirteen years, and Victoria, where the minimum for females is fifteen years. The general object of the restrictions imposed is to assure that a proper period shall be devoted to primary education, and that the early years of toil shall not exhaust the worker before the attainment of full growth. It is obvious that the age of apprenticeship in each State must be limited by the conditions governing the employment of child labour in factories. The early Apprentices Acts in some of the States are apparently in conflict on this point with the Factories Acts. The statutes limiting the age at which children may begin to work may be regarded as applicable by way of preventing too early apprenticeship, so also may those directing that education be continued up to a certain age or standard. Indentures must be entered into specifying the conditions of the employment. Apprenticeships may not exceed seven years in duration, and become inoperative at 21 years of age, or in the case of women, on marriage. The Arbitration Courts and Wages Boards have power to limit the number of apprentices which may be employed in a factory.

All the States have statutes containing provisions respecting the hours during which shops in large centres may be kept open for business. These provisions, in effect, not only limit the hours during which shop-hands may be employed, but apply also where the shops are tended by the proprietor alone, or by himself and family, with, however, certain exceptions. In Victoria, for example, shops wherein not more than one assistant, whether paid or not, was employed, were permitted to remain open for two hours a day longer than other shops of the same class. The object of this was to relieve the hardship which existed for such persons as, for example, widows who were wholly dependent for a livelihood upon the casual trade of small shops. It is, however, reported that little or no benefit accrued from the permission. In each of the States the closing time of shops, except those specially exempted, is 6 p.m. on four days of the week, 10 p.m. on one day (except 9 p.m. in Queensland, South Australia, and Western Australia), and 1 p.m. on one day—thus establishing a weekly half-holiday. In Western Australia the opening hour is fixed at 8 a.m. In addition to fixing the closing hour, the total daily and weekly working hours are delimited in the case of women and children. In some States, butchers' shops must be closed an hour earlier than other retail establishments, the reason being the early hour at which assistants must start to attend to the markets and early morning trade.

Establishments, the opening of which in the evening is presumably necessary for public convenience—such as hotels, restaurants, chemists' shops, etc.—are required to remain open for longer hours or are permitted to do business during hours prohibited in other establishments.

The provisions of the early closing laws differ somewhat in each State, but the main objects, namely, the restriction of long hours of labour, are identical throughout. Formerly, in some of the States, there were, and there are still in others, provisions making the early closing of a business, or the selection of a day for a half-holiday, dependent upon the option of the majority of the business people concerned, or upon the local authority. The anomalous results of the system whereby shops on one side of the street bounding two municipalities were open, when those upon the other side were closed, led to the introduction of the compulsory system, whereby the hours of business are absolutely fixed by statute. In Queensland, the day of the weekly half-holiday is fixed for Saturday. In Victoria also the Saturday half-holiday became compulsory in 1909, and in New South Wales in the following year, and there is a strong movement throughout the Commonwealth in favour of closing on the afternoon of that day. The hours for shops exempted from the general provisions of the Acts are also prescribed, and special holidays are provided for carriers.

The provisions of Factories and Shops Acts and of the Early Closing Acts in some of the States are consolidated under a single Act, but in others are separate enactments. The chief provisions of the principal Acts for registration, administration, record-keeping, etc., and of regulations under those Acts, are set out in the following summary :—

(*a*) Factories are defined to be places where a certain number of persons are employed in making or preparing goods for trade or sale, or in which steam or other power is employed, or where

special classes of industry are carried on. In some States the employment of a Chinese, in some of any Asiatic, constitutes the place a factory.

(*b*) A Minister of the Crown administers the Act in conjunction with a Chief Inspector of Factories. Inspectors visit the factories with full powers of entry, examination, and enquiry; these are of both sexes, females being employed in that portion of the work where a woman is particularly necessary. Broadly speaking, these powers confer upon the Inspector the right to enter, inspect, and examine, at all reasonable hours by day and night, any factory where he has reason to think anyone is employed; to take a police constable, if necessary, to assist him in the execution of his duty; to require the production of all certificates, documents, and records kept by the occupier, in accordance with the terms of the enactments; to examine, either alone or in the presence of any other person, every person whom he finds in a factory; to make whatever examination he deems necessary to ascertain whether the provisions of the Act are complied with.

(*c*) Registration of factories before occupation is compulsory. Description of premises and statement of the work to be done must be supplied, and a certificate of suitability of premises obtained.

(*d*) A record of all employés, giving the names, ages, wages, and work of each under a certain age (18, 20, 21, etc.), must be kept and filed in the Chief Inspector's office.

(*e*) Names and addresses of district inspectors and certifying medical practitioners must be posted; also the working hours, the holidays, and the name, etc., of the employer.

(*f*) Records of out-work must be kept, containing the names and remuneration of workers, and stating the places where the work is done. Out-workers are required to register.

(*g*) Places in which only the near kin of the occupier are employed are generally exempt from registration.

(*h*) Meals may be prohibited in workrooms, etc. In some States occupiers are required to furnish suitable mealrooms.

(*i*) The employment in factories of young children is forbidden, and medical certificates of fitness are required in the case of young persons under a certain age. Special permits, based on educational or other qualifications, may be issued for young persons of certain ages.

(*j*) Guarantees of an employé's good behaviour are void unless made with the consent of the Minister.

(*k*) Persons in charge of steam engines or boilers must hold certificates of service of competency.

(*l*) Provision (safeguarding against accident) is made for the fencing off and proper care of machinery, vats, and other dangerous structures. Women and young persons are forbidden to clean

machinery in motion or work between fixed and traversing parts of self-acting machinery while in motion ; and dangerous trades are specified in which a minimum age is fixed. Notice of accidents must be sent to the district inspector. (Dangerous trades are generally under the administration of Boards of Health.)

(*m*) Provision is made for the stamping of furniture, the object being to disclose whether it is made by European or Chinese labour.

(*n*) Minimum wage provisions are inserted. Premiums to employers are forbidden.

(*o*) Sanitation and ventilation must be attended to, and fresh drinking water supplied. Separate and adequate sanitary conveniences for each sex are required.

(*p*) Shopkeepers are required to provide proper seating accommodation for female employés. (In some States this is the subject of special legislation.)

(*q*) A dressing-room for females must be provided in factories the manufacturing process of which requires a change of dress.

(*r*) Adequate protection must be made against fire, and efficient fire-escapes provided.

(*s*) Wide powers of regulation are granted to the Executive and heavy penalties imposed, including a penalty by way of compensation to any person injured or the family of any person killed through failure to fence machinery and other dangerous structures.

Other measures for the protection of life, health, and general well-being of the worker exist in most of the States. Though in some instances founded upon English legislation, many of the provisions are peculiar to Australia. Despite experience and continued amendment they have not even yet attained to a settled form. Of the Australian States, Victoria originally had the most complete system of industrial legislation. Other States gradually adopted the Victorian statutes, either *en bloc* or with amendments suggested by local conditions. The results of the legislation referred to must be sought in the Reports of the Inspectors of Factories of the several States. Generally speaking, the perusal of these reports and of the reports of Royal Commissions which have inquired into the working of the Acts, affords satisfactory evidence that the Acts have, on the whole, effected their objects.

4.—Manufacturing Industries.

The statistics of manufactures in the Commonwealth during recent years show that many industries have now been permanently established on a secure basis, and also indicate a consistent progress both in regard to the extension of existing industries and the establishment of new ones. The scale on which many manufactories are established in Australia naturally appears small in comparison with that of similar establishments in older countries of the world ; but it should be remembered that the scope of

Australian manufactories is necessarily limited by the comparative sparseness of the population, and that, prior to 1901, development was retarded by the existence of intercolonial tariffs.

Soon after the discovery of gold, the construction of the first railways (1854) and the re-establishment of regular steam-ship communication with Europe (1856) helped to encourage the nascent industrial activity. The Colonies of New South Wales and Victoria, which had recently (1855) received the benefits of responsible government, soon turned their attention to the settlement of an agricultural population on the land. The Acts which were passed had a beneficent effect on the working classes, giving them opportunities for employment not previously open to them, and fostering the manufacturing industries by increasing the measure of primary production. During the following years the various manufacturing industries prospered. The statistics of the States are not sufficiently complete or uniform to enable a statement of the progress of these industries to be given. The following table, however, showing, so far as returns are available, the number of factories and the number of employés in each State at decennial periods since 1861, will serve to indicate generally the progress which has been made:—

NUMBER OF FACTORIES AND EMPLOYÉS IN EACH STATE, 1861 TO 1911.

Year.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia	Tasmania.	Commonwealth.
			Number of Factories.				
1861	601	531	..	..	..	..	..
1871 .. .	1,813	1,740	..	..	..	..	..
1881	2,961	2,488	571†	823†	..	..	..
1891	3,056	3,141	1,328†	996†	175	..	..
1901 .. .	3,367	3,249	2,110†	1,335†	662	420*	11,143‡
1911	5,039	5,126	1,657	1,314	710	609	14,455
			Number of Employés.				
1861 .. .	..	4,395	..	..	..	.	.
1871	13,583	19,569	..	5,629†	..		.
1881	31,191	43,209	..	10,995†	..	.	..
1891 . ..	50,879	53,525	..	14,099†	..	..	..
1901	66,135	66,529	26,172†	19,283†	12,198	7,466*	197,783‡
1911	108,664	111,948	37,156	27,907	15,799	10,298	311,772

* For 1902. † Not on same basis as other States. ‡ Not on same basis for some of States as in 1911.

Since the inauguration of the Commonwealth, the throwing open of the whole of the Australian markets to the industrial products of each State has facilitated the internal distribution of the products of Australian industry.

From the above table it will be seen that the total number of factories in the Commonwealth in 1911 was 14,455, employing 311,772 hands. There are 2,033 factories employing less than four persons each, and 1,533 which

employ only four. At the other end of the scale there are 677 establishments employing 48,038 people (from 51 to 100 per factory), and 526 employing 119.626 (over 100 each).

Under the classification adopted at the Conference of Statisticians held in 1906, factories were placed under nineteen different categories, according to the nature of the industry carried on therein; many of the categories were also subdivided. Where two or more industries are carried on by one proprietor in one building, each industry is, when possible, treated as a separate establishment. The statement given below shows the number of factories, the number of employés, the amount of wages, value of land, plant, etc., and of output according to the classification which has been adopted; it must be understood, however, that this classification does not pretend to be exhaustive, but merely serves as a guide for the collection and presentation of statistics in the several States on a definite and uniform basis.

COMMONWEALTH MANUFACTORIES, 1911.

Class of Industry.	No. of Establishments.	No of Hands Employed	Salaries and Wages Paid (000 omitted).	Value of Land and Buildings Used (000 omitted).	Value of Plant and Machinery (000 omitted).	Value of Output (000 omitted).
	No.	No	£	£	£	£
I. Treating Raw Material, product of Agricultural and Pastoral Pursuits	857	9,805	808,	979,	878,	9.983,
II. Treating Oils and Fats (Animal, Vegetable, &c.)	105	2,019	175,	445,	435,	2,042,
III. Processes in Stone, Clay Glass, &c.	719	12,093	1,225,	1,229,	1,300,	2,964,
IV. Working in Wood	1,625	27,948	2,851,	1,668,	2,208,	8,853,
V. Metal Works, Machinery, &c.	1,697	60,538	6,829,	5,000,	5,723,	25 856,
VI. Connected with Food and Drink	2,310	45,623	4,154,	8,167,	8,571,	45,122,
VII. Clothing and Textile Fabrics..	3,093	83,845	4,737,	4,602,	1,538,	16,054,
VIII Books, Paper, Printing, and Engraving	1,144	24,292	2,379,	2,964,	2,482,	6.307,
IX. Musical Instruments, &c. ..	19	607	66,	82,	18,	190,
X. Arms and Explosives ..	14	508	38,	42,	56,	147,
XI. Vehicles and Fittings, Saddlery, Harness, &c. .. .	1 208	13,294	1,114,	1,453,	283,	3,021,
XII. Ship and Boat Building and Repairing	87	2,920	362,	1,163,	478,	664,
XIII. Furniture, Bedding, and Upholstery..	613	9,502	879,	898,	178,	2,614,
XIV. Drugs, Chemicals, and By-products	189	4,165	269,	760,	602,	2,536,
XV. Surgical and other Scientific Instruments	41	233	20,	62,	11,	61,
XVI. Jewellery, Timepieces, and Plated Ware	169	2 142	209,	301,	62,	712,
XVII. Heat, Light, and Power ..	351	7 691	976,	2,320,	6,612,	4,311,
XVIII. Leatherware, n.e.i.	62	1,226	87,	112,	25,	509,
XIX. Minor Wares, n.e.i.	152	3,321	253,	251,	139,	1,240,
Total	14,455	311,772	27,431	32,498,	31,599,	133,186.

The above figures furnish some guide as to the importance of the manufacturing industries of the Commonwealth. The total value of the output for 1911 was £133,187,000, of which amount the sum of £79,012,000 represents the value of the raw materials used. The difference between these two amounts, viz., £54,145,000, represents the amount by which the value of the raw materials was enhanced in the process of manufacture. The total amount of salaries and wages paid in factories during 1911 was £27,532,000.

The largest number employed in any particular class in the Commonwealth was in Class VII., in which there were 83,845 employés, or 26·9 per cent. of the whole number. The class affording employment to the smallest number of hands was Class XV., in which there were 233 hands, or 0·07 per cent. of the total number of employés. Classes VI., VII., and VIII. comprise those industries in which female labour is largely employed.

The maximum amount of salaries and wages paid in any particular class was in Class V. (metal works, machinery, etc.), the amount being £6,829,000, or 24·8 per cent. on the total amount; the minimum amount was in Class XV. (surgical and scientific instruments), £20,000, or 0·07 per cent. on the total amount. The State in which the largest amount was paid was New South Wales.

The average amount of earnings per employé per annum has increased from £77·3 in 1907 to £92·2 in 1911. The figures for these two years for each State are as follow:—

MANUFACTURING INDUSTRIES—AVERAGE ANNUAL EARNINGS PER EMPLOYÉ.

State.	1907.	1911.
	£	£
New South Wales	80·6	96 3
Victoria	69·3	83·5
Queensland	72·1	87·1
South Australia	80·0	99·6
Western Australia	114 1	129·8
Tasmania	84 3	84·5
Commonwealth	77 3	92·2

In comparing the figures in the above table regard should be paid to the nature of certain industries which are carried on to a greater extent in some States than in others. In Victoria, for instance, where the average is lowest, there is a large number of factories and hands employed in Class VII. (clothing, etc.), and in that class wages are low, a great many women and children being employed. The position occupied by Western Australia is no doubt partly due to the higher cost of living in that State.

It will be noted that—except in Tasmania—there has been a considerable increase in the average earnings per employé in each of the States during the period under review, despite the tendency of the number of females employed in certain industries to increase at a higher ratio than males. Taking the Commonwealth as a whole, during the period 1907–11 there has been an increase of 50·25 per cent. on the total amount of wages paid and 19·31 per cent. on the average earnings per employé.

The amount expended in factories on fuel and light is of considerable importance; in 1911 it amounted to £2,753,000, being an increase on the previous year's figures of £118,000. The classes of industry in which fuel was most extensively used were Class V. (Metal Works, Machinery, etc.), £917,000; Class VI. (Food, Drink, etc.), £546,000; Class XVII. (Heat, Light, Power, etc.), £454,000, of which amount £374,000 was expended on generating electric light and power, and Class III., £355,000, of which £278,000 was represented in brick and pottery works, etc., and glass factories

The total value of raw materials worked up (*i.e.*, exclusive of fuel, lubricants, etc.) in 1911 was £79,042,000, which represents 59·3 per cent. of the total value of the finished products (*see* below). The class in which the maximum value of raw materials was used was Class VI., "Connected with Food and Drink, etc.," the value being £33,306,000. The next important class in order of value was Class V., "Metal Works, Machinery, etc.," in which raw materials to the value of £13,824,000 were used. The class in which the minimum value appears is Class XV., "Surgical and other Scientific Instruments," the value being only £19,000.

The difference between the total value of the output (£133,187,000) and the value of the raw materials used (£79,042,000) represents the amount added to the value of the raw materials by the process of manufacture. This difference, £54,145,000, is the real measure of the value of production of manufacturing industries. The value of the production in each State and the value per employé and per head of population are as follow:—

MANUFACTURING INDUSTRIES—VALUE OF PRODUCTION, 1911.

State.	Value of Production (000 omitted).	No. of Employés.	Value of Production per Employé	Value of Production per Head of Mean Population.
	£		£	£
New South Wales ..	20,644,	108,664	190·0	12·4
Victoria	16,718,	111,948	149·3	12·6
Queensland	6,887,	37,156	185·4	11·2
South Australia	5,071,	27,907	181·7	12·3
Western Australia . ..	3,252,	15,799	205·8	11·3
Tasmania	1,573,	10,298	152·7	8·2
Commonwealth ..	54,145,	311,772	173·7	12·1

It may be seen that the State of New South Wales far outstrips the other States in the value of the production of her factories, the value being £20,644,000, or 38·1 per cent. on the total for the Commonwealth. The next State in order of value is Victoria, which produced 30·9 per cent.; the value of the output of Queensland was 12·7 per cent.; of South Australia, 9·4 per cent.; of Western Australia, 6·0 per cent.; and of Tasmania, 2·9 per cent. The four most important classes in order of value of output (Classes VI., V., VII., and I.) are the same as in order of value of raw materials used.

As the total value of the output for the Commonwealth was estimated at £133,187,000, there remained, after payment of £79,042,000, the value of the raw materials used, of £27,532,000 for salaries and wages, and of £2,753,000 for fuel, the sum of £23,860,000 to provide for all further expenditure and profits. These results are shown in the following statement:—

MANUFACTURING INDUSTRIES—COST OF PRODUCTION AND VALUE OF OUTPUT, 1911.

Particulars.	Total Amount (000 omitted)	Per Cent. on Total Value of Output
	£	Per cent.
Raw Materials used	79,042,	59·3
Fuel and Light	2,753,	2·1
Salaries and Wages	27,532,	20·7
All other Expenditure*	23,860,	17·9
Total Value of Output	133,187,	100·0

* Including interest and profits

In spite of the increased cost of labour and of raw materials, there is no indication that there has been any diminution in the percentage of profits derived from manufacturing industries during the past few years. Thus in 1908 the percentage of the total output available for interest, profits, advertising, and all other standing charges was 16·6; in 1907 it increased to 17·6, and in 1908 to 17·8, compared with a percentage of 17·9 shown in the above table.

As an indication of the permanent character and stability of the industries which have been established in the Commonwealth, it may be noted that the values of land and buildings and of plant and machinery used in the factories are rapidly increasing. Thus, for the whole Commonwealth, the total value of land and buildings and plant and machinery has increased from 1906 to 1911 by £17,274,000, *i.e.*, from £46,824,000 to £64,098,000. In 1911 the sum of £32,499,000 was invested in land and buildings occupied as manufactories, the remaining £31,599,000 being the value of the plant and machinery used in connexion therewith.

Of the total number of 311,772 hands employed in manufactories in 1911, 81,644 were females and 230,128 males. In New South Wales the ratio of the number of females employed in factories to the number of males during 1886 was about one to seven; in 1891 one to six; in 1903 it became about one to four; and is now rather lower than one to three. In Victoria the ratio of females to males during the year 1886 was about one to five. Five years later (1891) it was somewhat less, but in 1896 had increased to about one woman to three men, and at present is slightly over one to two. In the remaining States the ratios during 1911 were—Queensland and South Australia, a little under one female to every four males, Western Australia one to five, and in Tasmania one to six. The

proportion for the whole of the Commonwealth was just over one to three The employment of women is, however, largely confined to a few trades.

The great prosperity in clothing and textile industries is one of the main causes of increase in female employment. Certain trades are specifically known as women's trades, such as clothing and textile trades, preparation of food, book-binding, and lighter work connected with the drug trade, as for example wrapping. In common with commercial establishments, a considerable number of women is also employed as clerks and typists in factories.

The proportion of the sexes in Australian factories has not materially changed during the past five years, the ratio of females to every hundred males employed having increased only from 34·6 in 1907 to 35·5 in 1911, and this slight increase has been due not so much to the incursion of female labour into what may be termed men's trades, as to the activity in those trades in which women are ordinarily engaged, more especially in dress-making, millinery, etc.

In the statistical compilations of the various States the term "child" may be taken to denote any person under sixteen years of age, excepting in New South Wales, where it denoted, for years prior to 1907, any person under fifteen. Since 1907 there had been an increase in the average number of children employed in every State, with the exception of Victoria and South Australia, there being a decrease of 1780 in the former and 53 in the latter State. The aggregate result for the Commonwealth is that the total number of children employed in factories has decreased from 14,622 in 1907 to 13,921 in 1911.

In each of the States, however, a comparison between the number of child-workers and the total number of persons employed shows a fairly regular decrease in the percentage of child labour. The 1908 and subsequent returns for Western Australia show a considerable increase over the 1907 figures; this increase occurred mainly in clothing and other light industries in 1908, and has since shown a slight diminution. For the whole Commonwealth the percentage of children employed in factories on the total number of hands employed has shown a regular decrease from 5·9 per cent. in 1907 to 4·5 in 1911.

The preceding remarks and tables furnish a general view of the stage of development which manufacturing industries have attained in Australia. In order to make the information more complete, it must necessarily be supplemented by details exhibiting the development of individual industries. This alone will furnish adequate information as to the channels into which the main efforts of Australian manufacture flow. Since it is not possible, within the limits of this article, to give anything like a detailed account of the manufacturing industries of the Commonwealth, the following table has been prepared, so as to show, in summarized and comparative form, certain particulars regarding industries of special importance by reason of the number of persons employed, the number of factories, the amount of capital invested therein, the value of the production, or other features of special interest.

PARTICULARS OF MORE IMPORTANT MANUFACTURING INDUSTRIES IN COMMONWEALTH, 1911.

Class of Manufactory.	No. of Factories.	No. of Employés.	Value of Land and Buildings, Plants, &c. (000 omitted).	Value of Raw Materials used (000 omitted).	Value of Fuel and Light (000 omitted)	Salaries and Wages (000 omitted).	All other Expenditure, Interest, and Profits (000 omitted).	Total Value of Output. (000 omitted).
			£	£	£	£	£	£
Tanneries	176	3,247	585	2,099	22	352	245	2,698
Soap and Candle	81	1,668	674	1,019	32	149	388	1,588
Saw Mills	1,494	26,785	3,675	4,208	37	2,749	1,542	8,536
Agricultural Implements	155	5,156	529	811	32	551	262	1,656
Engineering Works, &c	820	22,539	3,286	2,832	179	2,345	1,261	6,615
Railway Workshops, &c.	72	17,425	3,469	1,939	70	2,163	461	4,633
Smelting Works, &c.	143	7,036	2,244	6,618	608	1,043	1,840	10,109
Bacon Curing	73	912	261	1,186	12	105	210	1,513
Butter, Cheese, &c.	540	3,730	1,453	8,341	68	375	648	9,432
Ice and Refrigerating, &c	197	6,146	2,660	5,637	110	622	677	7,046
Biscuit	37	3,329	416	783	20	216	302	1,321
Jam and Fruit Preserving, &c	120	4,352	409	1,150	17	246	305	1,698
Confectionery	95	3,480	490	844	15	229	263	1,351
Flour Mills	233	2,915	1,791	6,078	79	342	583	7,082
Sugar Mills	53	4,764	2,691	1,215	57	404	531	2,207
Breweries	121	3,450	2,440	1,274	69	483	1,493	3,319
Distilleries	32	220	283	115	7	25	100	247
Tobacco, Cigar, and Cigarette	33	3,730	588	1,468	4	346	701	2,519
Woollen and Tweed Mills	32	3,200	762	430	20	203	171	824
Boots and Shoes	341	13,772	956	2,151	17	1,097	449	3,714
Hats and Caps	82	3,856	347	364	11	257	136	768
Coach and Waggon	765	8,030	958	720	25	659	335	1,739
Furniture and Cabinet Making	426	6,918	763	737	12	674	278	1,701
Electric Light and Power	164	2,432	3,965	..	374	325	964	1,663
Gas and Coke	136	4,125	4,628	715	73	571	1,003	2,362

5. Trade and Commerce.

Under the provisions of the Commonwealth Constitution Act, power to make laws with respect to "trade and commerce with other countries and among the States" was conferred on the Commonwealth Parliament. It was also provided that on the establishment of the Commonwealth, Customs and Excise duties should pass to the Commonwealth, uniform Customs duties should be imposed within two years, and that on the imposition of such uniform duties, trade and commerce between the States should be absolutely free. The first Act passed under the authority of these provisions was the *Customs Act* 1901. This provided for the establishment of the necessary administrative machinery for all matters pertaining to the Customs, and prescribed, *inter alia*, the manner in which Customs duties should be computed and paid. It did not, however, determine the rates of duty. During the interval between the inception of the Commonwealth, on the 1st January, 1901, and the coming into operation of the *Customs Act* 1901, the Customs Acts of the several States were administered by the Executive Government of the Commonwealth, under section 86 of the Constitution. The first Commonwealth Customs Tariff imposing uniform rates of Customs duty in all the States was introduced in the House of Representatives on the 8th October, 1901. "An Act relating to Duties of Customs," assented to on the 16th September, 1902, made provision that uniform duties of Customs specified in the Tariff schedule should be imposed from the 8th October, 1901. From this time onwards trade between the States became free, with, however, the exception, under section 95 of the Constitution Act, of the right of Western Australia to levy

duty on the goods from other States. The second Federal Tariff, succeeding the Kingston Act of 1901, came into force in 1907. The Commonwealth follows the British custom of enforcing a Tariff from the time it is presented to Parliament, modifying the rate of duty collected, if necessary, as the latter body passes the several items. The revision was in the direction of increased protection, though the free list was actually extended and a tariff of preferential rates was provided on goods produced or manufactured in the United Kingdom. The general effect of the tariff is disclosed by comparing the results obtained by applying to the imports of 1907 the rates of duty, first under the tariff of 1902 and, secondly, under that of 1908. This shows that the percentage of free imports on total imports (exclusive of bullion and specie) increased from 35·8 per cent. under the 1902 tariff to 40·7 under that of 1908, while at the same time the average rate of duty on *all* merchandise increased from 17·0 to 19·6 per cwt., and the average rate of duty on dutiable imports increased from 26·6 to 33·1 per cent.

The total value of the oversea trade of the Commonwealth amounted in the year 1912 to over £157,250,000, that is, to £33 17s. 2d. per head of population. After making due allowance for imports for transhipment or re-export, the value of the trade per inhabitant is greater in Australia (where it is £32 11s. 2d. per head) than in any other country in the world, except Belgium (£40 19s. 10d.), New Zealand (£37 10s. 4d.), and Switzerland (£32 11s. 3d.), and while it is true that external trade is not in itself necessarily an index of the prosperity of a country, a consideration of the general characteristics and of the marked development of the trade of the Commonwealth over a number of years suffices to show that Australian affairs are progressing rapidly and favorably, more especially when it is recognised that there are practically no factors operating in the opposite direction.

A review of the statistics of the total trade of the Commonwealth with oversea countries from the earliest date for which records are available (*i.e.*, the year 1826, when the value was £566,000, or £10 13s. 2d. per inhabitant), shows that there was a marked rise, followed by a sudden fall, in the value of imports during the period 1837 to 1844.* This was contemporaneous with heavy land speculation and a subsequent severe financial crisis. In the early 'fifties, consequent on the discovery of gold, there was a great increase in trade, the total value of imports and exports rising from £5,670,000 in 1851 to £15,694,000 in 1852, £29,393,000 in 1853, and £36,406,000 in 1854. This represents an increase per head from £13 9s. 2d. in 1851 to £56 3s. 10d. in 1854. The rapid influx of persons anxious to share the good fortunes of these times soon reduced the value of the trade per head, until, by 1858, it had declined to £31 19s. 6d., while the period 1867 to 1872 again shows a marked reduction in the value per head. For some years prior to this period a succession of indifferent seasons had been experienced in New South Wales, while in Victoria the labour market was congested, owing to the decline in alluvial gold-mining.

An examination of the movement of the oversea trade of Australia shows that periods of depressed trade have been recurrent at more or less regular intervals of from seven to nine years, and, measured by population, each succeeding depression since 1855 has carried the trade per head lower than

* See graph on page 462

the preceding one, until the lowest point was reached in 1894. The year 1892 marked the beginning of a period of acute financial stress, culminating in the commercial crisis of 1893. The collapse of these years is plainly reflected in the trade records of that period, the trade of 1894 falling to £54,028,000, a decline of no less than 26·7 per cent. in three years. In 1895 there was a slight recovery, and a continuous upward movement until 1901, when the trade reached £92,130,000, or £24 6s 1d per head. A decline, due to drought, in the exports of agricultural, pastoral, and dairy produce, reduced the trade of 1902 to £84,591,000, but although in the next year there was a further shrinkage in the exports of agricultural produce, the increase in the value of the exports of metals, specie, butter, and wool was so large as to effect an increase in the total trade. From 1902 the increase in the value of trade continued, until in 1907 it reached the amount of £124,633,000, equal to £30 4s. 5d. per inhabitant.

The imports during 1907 were, doubtless, to some extent inflated by the importation of goods in anticipation of the Tariff revision of that year. The trade of 1908 shows a decline of £10,523,000 as compared with 1907, of which £8,513,000 was in the value of exports, notwithstanding an increase of £3,448,000 in the export of gold and specie. This decline in the value of exports was largely due to reduced prices ruling for wool and metals in consequence of the financial crisis in the United States during the previous year, and in lesser degree to the smaller exports of agricultural and pastoral produce, due to the unfavorable season experienced in some of the States.

The trade of 1909 per head of population was slightly more than in 1908, notwithstanding that the gold exports were less by £5,194,000. In 1910 the trade reached an absolute value never before attained, while, measured by the population, the value of imports per head was higher than in any year since 1885 and the value of exports was—excepting the years 1906 and 1907—the highest since 1857. The high value of exports is particularly striking when considered in conjunction with the exceptionally small exports of gold. The latter, already much reduced in 1909 as compared with 1908, decreased still further in 1910 to £4,109,000, the smallest recorded since 1892. These relatively small exports of gold do not indicate the decline of the gold production, but are merely due to the fact that the recent prolific seasons and high prices made the exports of merchandise sufficient to meet all obligations abroad and so render the export of gold unnecessary. During 1911 the exports of gold bullion and specie again increased to £11,541,000.

With few exceptions, due to temporary dislocations of trade, the balance of trade prior to 1892 was on the side of imports, but from 1891 the reverse has been the case, the value of exports having increased by 120·5 per cent., and the imports by 77·6 per cent. The excess of imports in the earlier years represents the introduction of capital in the form of Government loans and for investment in private undertakings, and the excess of exports in the later years represents mainly the interest and profit on the earlier investments, repayment of loans to foreign bondholders, and also freight on trade which is carried mainly by ships of the United Kingdom. The continued increase in the value of imports during 1912, while the value of exports remained stationary, is largely due to increased loan flotations in London, and also in some degree to the larger introduction of capital by immigrants.

The total value of the Commonwealth's exports in 1912 was £79,096,000, of which the United Kingdom accounted for £31,459,000, British possessions for £16,888,000, and foreign countries for £30,749,000. As may be seen from the following table, considerable alteration in the direction of exports is evident in the figures for the last twenty years.

COMMONWEALTH'S EXPORTS, 1891 TO 1912—PURCHASING MARKETS.

Period.	To— United Kingdom (000 omitted).	British Possessions (000 omitted).	Foreign Countries (000 omitted).	Total (000 omitted).
	£	£	£	£
1891–5	23,804,	2,812,	7,067,	33,683,
1896–1900	24,624,	5,067,	11,402,	41,093,
1901–5	23,930,	13,507,	13,800,	51,237,
1906–10	32,984,	10,754,	25,598,	69,336,
1911	35,310,	15,825,	28,347,	79,482,
1912	31,459,	16,888,	30,749	79,096,

It may be remarked that the decrease in the value of exports shipped to the United Kingdom in 1912 is largely due to the diminished production in Australia (owing to the drought in that year) of several important commodities which are exported mainly to the United Kingdom. For example, the value of the exports of wheat decreased by £2,037,000, wool by £741,000, and butter £1,309,000. The exports of bullion and specie also decreased by £662,000.

These figures show that the value of foreign markets to Australia is increasing at a much greater rate than the value of the export trade to the United Kingdom. The South African Union, India, and Ceylon are largely responsible for the increases in exports to British possessions. During the South African war large shipments of gold were sent from the Commonwealth to that country, and the more recent decline in the value of the exports to South Africa is due to the cessation of these shipments together with a decrease in the export of timber. The exports to India and Ceylon are also mainly of gold, of which exceptionally heavy shipments were made during 1904, 1905, and 1911; the large increase in exports to foreign countries occurred mainly with respect to Belgium, Germany, and France.

Notwithstanding an increase of 32·2 per cent. in the actual value of exports to the United Kingdom during the year 1912, as compared with the yearly average of the period 1891–95, the proportion of the total exports despatched to the United Kingdom has fallen from 70·7 per cent. in the earlier period to 39·8 per cent. in the year 1912. This decrease, and the corresponding increase in the export trade to foreign countries, are to some extent, undoubtedly due to the fact that wool and other commodities which were formerly despatched to the United Kingdom, and distributed from that centre, are now to a greater extent shipped direct to continental parts.

The figures given, however, do not even now denote the total purchases by foreign countries of Australian produce, as large quantities are still distributed from London.

The foregoing table shows a great increase in the value of exports to foreign countries, both in actual amounts and in relation to total exports. The value of exports to foreign countries during 1912 shows an increase of 335 per cent. over similar figures for the years 1891–5, thus increasing the proportion per cent. of all exports from 20·9 per cent. in the earlier years to 38·9 per cent. in 1912.

In order to show the general development and nature of Australia's export trade, the following table is given, in which the exports are arranged according to class, the usual distinction being made between Australian produce and re-exports.

COMMONWEALTH EXPORTS ARRANGED IN CLASSES, 1901 AND 1912.

Classes	Australian Produce		Other Produce		Total Exports	
	1901 (000 omitted).	1912 (000 omitted).	1901 (000 omitted).	1912 (000 omitted).	1901 (000 omitted).	1912 (000 omitted).
	£	£	£	£	£	£
I. Animal Foodstuffs, &c.	4,104	7,991	35,	24	4,139,	8,015,
II. Vegetable Foodstuffs, &c. ..	4,633	8,741	81	170	4,714	8,911,
III. Beverages (non-alcoholic), &c.	3	5,	43	78	46	83,
IV. Alcoholic Liquors, &c. ..	134,	132,	56	42,	190,	174
V. Tobacco, &c. ..	5	79	62	52,	67,	131,
VI. Live Animals .	474,	328,	.	5	474,	333,
VII. Animal Substances, &c. .	16,754,	31,283	10,	6,	16,764,	31,289,
VIII. Vegetable Substances, &c. .	142	174,	18,	66,	160,	240,
IX. Apparel, &c.	42	77,	171,	204,	213	281
X. Oils, &c. ..	844	1,846	42,	52,	886,	1,898,
XI. Paints, &c. .	1,	7,	15,	8	16,	15
XII. Stones, &c.	1,042,	1,161,	2	2,	1,044,	1,163
XIII. Specie ..	8,885	9,058	847	1,420,	9,732,	10,478,
XIV. Metals (unmanufactured) Ores, &c. .	8,916	12,364	10,	24,	8,926,	12,388,
XV. Metals (part manufactured)	4,	19,	14	25,	18	44,
XVI. Metals (manufactured) .	118,	303	196	269	314,	572,
XVII. Leather, &c. .	661,	716,	13	55,	674,	771,
XVIII. Wood, &c. .	666,	908,	32,	34,	698,	942,
XIX. Earthenware, &c.	7	19,	23,	16,	30,	35,
XX. Paper, &c. ..	22,	72,	52,	112,	74,	184,
XXI. Jewellery, &c.	68	171,	54	87	122	258,
XXII. Instruments, &c. ..	1,	6,	13	93,	14,	99,
XXIII. Drugs, &c.	86,	268,	43	55,	129,	323,
XXIV. Miscellaneous	130,	235	122,	234	252,	469,
Total	47,742	75,963	1,954	3,133,	49,696	79,096,

From the above table it will be seen that there has been a very substantial expansion in the principal divisions of the export trade of the Commonwealth. Compared with 1901 the exports in 1912 of animal foodstuffs, principally butter and meat, show an increase of 93·7 per cent. ; vegetable foodstuffs, principally wheat, show an increase during the same period of 89·1 per cent. ; animal substances—wool, skins, etc.—show an increase of 86·7 per cent. ; oils, fats, and waxes—mainly tallow—an increase of 114·2 per cent. ; and wood, etc. (timber) an increase of 35·0 per cent.

While Australia's exports are chiefly the product of the agricultural, pastoral, and mining industries, there is some promise of the Commonwealth exporting a substantial quantity of manufactured articles to the Eastern and island markets, as well as to those countries which produce similar foodstuffs and raw materials, for the raising and handling of which Australia has evolved and now manufactures special machinery and goods.

During recent years attention has accordingly been given by Australian exporters to the possibilities of these markets. Commissioners have been

sent by the States to Eastern trade centres to investigate and advise as to the requirements of these markets in regard to such commodities as Australia is prepared to supply, and a survey of the export returns of the past decade discloses a very material expansion in the value of the exports of merchandise in the direction indicated. The principal countries concerned in this trade are China, India, Ceylon, Japan, Java, Philippine Islands, Straits Settlements, and Hong Kong.

The total value of imports into Australia in 1912 was £78,159,000. As regards countries of shipment, the value of goods consigned from the United Kingdom was £45,925,000, from British possessions £9,581,000, and from foreign countries £22,653,000. Classified according to country of origin, however, the imports from the United Kingdom were valued at £39,125,000, from British possessions at £8,614,000, and from foreign countries at £30,381,000.* The following table indicates the expansion in the import trade which has taken place since the year 1891 :—

COMMONWEALTH IMPORTS, 1891 to 1912—COUNTRIES OF SHIPMENT.

Period.	From— United Kingdom (000 omitted)	British Possessions (000 omitted).	Foreign Countries (000 omitted).	Total (000 omitted)
	£	£	£	£
1891–5	19,481,	3,177,	4,677,	27,335,
1896–1900.. ..	21,798,	3,747,	8,218,	33,763,
1901–5	22,896,	5,005,	11,356,	39,257,
1906–10	31,246,	6,919,	13,343,	51,508,
1911	39,499,	8,612,	18,856,	66,967,
1912	45,925,	9,581,	22,653,	78,159,

The foregoing tables show that while the actual value of direct imports from the United Kingdom during 1912 is above the yearly average of the period under review, being more than double that of the quinquennium 1891–5, the proportion to total imports has diminished, having fallen from 71·3 per cent. during the years 1891–5 to 58·8 per cent. in 1912. The position of the United Kingdom as indicated by her percentage proportion of the total trade is largely affected by the imports of vegetable foodstuffs, a branch of trade in which the United Kingdom cannot participate. The apparent diversion of Australian trade from Great Britain is more fully dealt with in a later part of this article. The growth of the value of imports from other British possessions during the past twenty years has been such as to increase the proportion to total imports from 11·6 per cent. in the years 1891–5 to 12·3 per cent. in 1912. Of the total imports from British possessions during 1911–12, 35·0 per cent. was from New Zealand, 22·0 per cent. from India, 11·3 per cent. from Canada, and 9·0 per cent. from Ceylon. The imports direct from foreign countries during the year 1912 represented 28·9 per cent. of the total imports, as compared with 17·1 per cent. during the years 1891–5. Of the total imports into Australia shipped from foreign countries, 22·7 per cent. was from Germany, and 41·7 per cent. from the United States.

* In addition, the value of Australian produce re-imported was £39,000, making up the total to £78,159,000

An examination of the various categories with which imports are classified shows that, as regards value, about 46·7 per cent. of the total imports are included in the two classes—(a) Apparel, textiles, and various manufactured fibres, and (b) metals manufactured, including machinery. The following table shows the value of imports in 1901 and 1912, classified under twenty-four categories:—

COMMONWEALTH IMPORTS ARRANGED IN CLASSES, 1901 and 1912.

Classes	1901 (000 omitted)	1912 (000 omitted).	Increase. Value (000 omitted).	Increase. Per Cent.
	£	£	£	
I. Animal Foodstuffs, &c.	793,	1,038,	245,	30·8
II. Vegetable Foodstuffs, &c.	2,926	4,456,	1,530,	52·2
III. Beverages (non-alcoholic), &c.	1,055,	1,864,	809,	76·6
IV. Alcoholic Liquors, &c.	1,846,	2,023,	177,	9·5
V. Tobacco, &c.	718,	1,046,	328,	45·6
VI. Live Animals	40,	244,	204,	510·0
VII. Animal Substances, &c.	124,	337,	213,	171·7
VIII. Vegetable Substances, &c.	459,	1,494,	1,035,	225·4
IX. Apparel, &c.	12,066,	19,496,	7,430,	61·5
X. Oils, &c.	1,290,	2,192,	902,	69·9
XI. Paints, &c.	385,	677,	292,	75·8
XII. Stones, &c.	131,	201,	70,	53·4
XIII. Specie	173,	543,	370,	213 8
XIV. Metals, Ores, &c.	984,	1,488,	504,	51·2
XV. Metals, part manufactured	1,062,	1,424,	362,	34·0
XVI. Metals, manufactured	7,492,	16,985,	9,493,	126·7
XVII. Leather, &c.	524,	1,788,	1,264,	241·2
XVIII. Wood, &c...	1,814,	3,565,	1,751,	96·5
XIX. Earthenware, &c.	925,	1,445,	520,	56·2
XX. Paper, &c.	1,731,	3,116,	1,385,	80·0
XXI. Jewellery, &c.	1,065,	1,874,	809,	75·9
XXII. Instruments, &c.	219,	518,	299,	136·5
XXIII. Drugs, &c...	1,472,	2,394,	922,	62·6
XXIV. Miscellaneous	3,140,	7,951,	4,811,	153·2
Total	42,434,	78,159,	35,725,	84·2

6. Trade of the United Kingdom with Australia.

The failure of the United Kingdom to maintain the position formerly held by her in the import trade of Australia has, during recent years, become a matter of more than ordinary interest in both countries. In June, 1905, Mr. R. J. Jeffray was sent here as a "Commissioner of the Advisory Committee on Commercial Intelligence of the British Board of Trade," to investigate the conditions and prospects of British trade with this country, and early in 1908 Mr. Ben H. Morgan was sent on a similar mission by the Manufacturers' Association of Great Britain, and in particular to report on :—(i.) The extent and possibilities of the market, with a view to (a) increasing export trade, (b) establishing branch factories inside the tariffs; (ii.) the extent and condition of local industries: (iii.) the nature and condition of foreign competition; (iv.) transport services, with special reference to shipping "rings" and "conferences"; (v.) the operation of local tariffs and effects

of preferences. In December, 1908, a permanent Commissioner of the British Board of Trade arrived in Australia for the purpose of advising British manufacturers of the particular requirements of the Australian markets, with a view to improving the trade between the Commonwealth and the United Kingdom.

In his report Mr. Jeffray gave the following principal causes of the success of the foreign manufacturer in the Australian market:—(i.) Greater promptitude and attention to orders; (ii.) greater readiness to adapt their goods to the requirements of customers; (iii.) more efficient representation in Australia; (iv.) better package of goods; (v.) more attractive appearance of goods; (vi.) lower freights.

Mr. Morgan reports "that the most important reason for the growth of foreign trade in Australia is that the foreign manufacturer is able to quote lower prices than the British manufacturer for goods of equal value." That the foreign manufacturer is able to do this, is, he contends, due to the following, viz.:—(i.) *Protection.* By virtue of protection for his home market "the foreign manufacturer can depend on a definite consumption therein, and is thus able to produce in larger quantities, and therefore more cheaply." (ii.) *Lower shipping rates and raw materials.* "Direct shipping services have been established with foreign countries, who carry goods generally at lower rates than British shipping companies carry British goods, and that, following the developemnt of manufacturing industries in foreign countries and the establishment of those cheap shipping facilities, the markets for raw materials are being diverted to those countries . . . and by carrying at lower rates, give their manufacturers an advantage in price in such raw materials." After quoting instances of goods being charged freights from Liverpool to Australia much above those charged on similar goods from New York to Hamburg *viâ* Liverpool to Australia, Mr. Morgan says:—"This shipping question is one of vital interest to manufacturers, and the time has come when they must, if they are to retain their position in export markets, interest themselves directly in freight matters, instead of leaving them as heretofore to merchants and shipping agents."

Mr. Wickes, addressing the British delegates attending the seventh Congress of the Chambers of Commerce of the Empire, alluding to freights, said:—"I doubt if there is any question which so illustrates the want of organization among our commercial community," and he suggested that there should be a keener study of freight rates from other parts of the world, and also closer co-operation of British manufacturers, for the more economical distribution of their manufactures. In subsequent reports, Mr. Wickes strenuously advocates more direct representation of British manufacturers in Australia.

In order to draw any reliable conclusions as to the growth of import trade from the United Kingdom as compared with that from other countries, it will be desirable to furnish a comparison free from the influence of such trade as is, in the nature of the case, not open to the United Kingdom. For if the total imports were included in any such comparison, the results would be subject to certain limitations imposed by the nature of the imports from some countries. For example, the total imports from the United States have been increased in certain years by imports of breadstuffs, while imports of such

items as kerosene and timber also increase the proportion of imports from the United States without any prejudicial effect on the trade of the United Kingdom. Similar modification is not necessary in regard to Germany, as the nature of the imports from that country is substantially the same as from the United Kingdom. The following statement shows accordingly the percentage on the total value of Commonwealth imports of the principal direct imports from the United Kingdom, Germany, and the United States during the years 1886, 1906, 1908 to 1910, and 1911. It should be observed that, prior to the year 1905, imports into the Commonwealth were recorded only against the country whence they were directly shipped. Although the values of *direct* imports do not afford completely satisfactory data (since the proportions of indirect trade vary to some extent), it is necessary in any comparison extending further back than 1905 to use such figures.

PERCENTAGE ON TOTAL COMMONWEALTH IMPORTS OF PRINCIPAL *Direct* IMPORTS FROM UNITED KINGDOM, GERMANY, AND UNITED STATES, 1886, 1906, 1910, AND 1911.

Nature of Imports	Year.	United Kingdom.	Germany.	United States.	All Countries.
Total imports of foodstuffs of animal origin, alcoholic liquors, apparel, textiles, boots, metal, paper and stationery, jewellery, timepieces, earthenware, cements, drugs, chemicals, fertilisers, and leather*	1886	89·31	1·65	3·01	100
	1906	71·98	7·94	7·79	100
	1908	71·29	7·66	8·84	100
	1909	72·70	7·10	7·12	100
	1910	71·04	6·91	8·07	100
	1911	69·91	7·16	8·95	100
Total imports (less bullion and specie)..	1886	73·71	2·06	6·16	100
	1906	62·34	7·55	10·92	100
	1908	61·11	7·32	12·42	100
	1909	62·10	6·64	9·98	100
	1910	61·82	6·44	11·07	100
	1911	60·28	6·82	11·93	100

* Representing over 70 per cent. of the total imports.

The foregoing table shows that the share of the United Kingdom, as indicated by the records according to "Country of Shipment," in the trade of those classes of goods enumerated—representing over 70 per cent. of the total imports from that country—has declined from 89·3 per cent. of the whole in 1886 to 70·0 per cent. in 1911. The value of these imports from the United Kingdom has increased from £20,489,000 in 1886 to only £32,038,000 in 1911, or by 56·4 per cent., while the total value of similar imports has increased from £22,938,000 to £45,826,000, or by 99·7 per cent. Had the same proportion of the total trade been shipped from the United Kingdom during 1911 as in 1886 it would have represented £40,927,000 instead of £32,038,000.

It has been suggested that the larger proportion of imports now received from foreign countries is due to the establishment and increase of direct shipping with the countries concerned, and that trade formerly received through English ports is now received direct. From the Australian records it is impossible to ascertain the value of the indirect trade with foreign

countries through the United Kingdom prior to 1905. The returns of the British Board of Trade, however, show that the percentage of foreign and colonial produce exported from the United Kingdom to Australia on the total exports was 14·26 in 1911, compared with 14·16 per cent. during the five years 1886 to 1890, and 13·52 per cent. during the 25 years 1886 to 1910.

It will be seen, therefore, that the average percentage of foreign goods despatched to Australia through the United Kingdom during 1911 is almost identical with the average of the years 1886–90, and is greater than the average of the past 25 years. It is therefore apparent that the increase of direct imports from foreign countries has not been, in the aggregate, at the expense of the indirect trade *viâ* Great Britain.

Preferential trade with Great Britain has been under discussion in Australia for many years, and the Tariff Act of 1908, at present in force, provides preferential rates in favour of goods produced or manufactured in the United Kingdom. On the introduction of the preferential treatment of British goods, it was required that British material or labour should represent not less than one-fourth the value of such goods. From the 1st September, 1911, it has been required, in regard to goods only partially manufactured in the United Kingdom, that the final process or processes of manufacture shall have been performed in the United Kingdom, and that the expenditure in material of British production and or British labour shall have been not less than one-fourth of the factory or works' cost of the goods in the finished state.

After an exhaustive analysis of the trade returns made in the *Official Year-Book of the Commonwealth* (No. 6, pp. 629 to 643), it is stated that the results do not disclose any positive effect of the preferential rate, one way or the other. It is further stated that there is every reason to believe that the records, in many instances, are not sufficiently accurate to allow of just comparisons being made, and that it will only be in the course of a number of years that anything like a definite opinion can be reached as to the efficiency of the preferential treatment, for, as Professor W. J. Ashley, in his preface to Mr. John Holt Schooling's *British Trade Book*, says—" No comparison of isolated years, no comparison of short consecutive periods, can be relied upon to give properly comparable data."

Primarily, it will be necessary in some way to eliminate the normal growth in business which would have taken place under any *régime* whatever in an advancing country; and secondly, the significance of the statistics will depend upon a very rigid adherence to the same method of description in regard to items and the same definition of " Origin." If the practice of recording is as variable in the future as it has been in the past, no real deductions can be drawn, and this goes to show the importance of maintaining the same method of describing items, quite irrespective of their significance from the stand-point merely of revenue.

In order to determine the course of trade, it will be essential to maintain in its integrity for a sufficient number of years any classification of items once adopted, and no practicable means of analysis will enable one to penetrate the significance of the trade if that course is not followed, because the

determining effect of a preference which, in its nature, is likely to be not too well marked compared with the other elements of growth, can easily be vitiated by the entering of other possibilities of change into the results.

7. Shipping.

The shipping of the Commonwealth has hitherto been conducted partly under Imperial Acts, consolidated in the Merchant Shipping Act of 1894, and amendments of these, and partly under Acts of the several States of the Commonwealth. By Part IV., section 98, of the Commonwealth Constitution Act, power to make laws with respect to trade and commerce was extended to navigation and shipping, and in pursuance of this power a Bill for an Act relating to Navigation and Shipping was introduced into the Senate on the 17th March, 1904, but was not proceeded with. After a Royal Commission in Australia and a conference between representatives of the United Kingdom, the Commonwealth of Australia, and New Zealand, in London, had been held on the subject of merchant shipping legislation, an amended Bill was introduced into the Senate in 1907, and eventually received the Royal Assent in August, 1913. The Act, which is to come into force on a date to be proclaimed, is based largely on the British Merchant Shipping Acts and the Acts of New Zealand and New South Wales, and contains 425 sections divided into eleven parts, as follows :— I. Introductory. II. Masters and Seamen. III. Foreign Seamen. IV. Ships and Shipping. V. Passengers. VI. The Coasting Trade. VII. Wrecks and Salvage. VIII. Pilots and Pilotage. IX. Courts of Marine Inquiry. X. Legal Proceedings. XI. Miscellaneous. Apart from important provisions relating to accommodation, manning, surveys, and pilotage, there are sections dealing with the safety of life at sea. It is provided that ships carrying 50 or more passengers engaged on journeys exceeding 200 miles from port to port are to be equipped, unless specially exempted, with efficient wireless installation.

An entirely new departure is marked by that portion of the Act dealing with the coasting trade. A ship is to be deemed as engaged in the coasting trade if she takes on board passengers or cargo at any port in a State or territory which is part of the Commonwealth, to be carried or delivered at any other port in the same State or territory or in any other State or other such territory. It is specially provided, however, that passengers can be carried on through tickets to such ports, and that cargo and mails can be similarly carried. This provision means that unless licensed in Australia for the coasting trade (which implies compliance with Australian conditions as to pay, manning, and so on), a ship, whether it be British or foreign, cannot carry passengers from one port of the Commonwealth to another. An English mail steamer, calling first at Fremantle, could not carry passengers thence to Adelaide. There is, however, a further provision that the Governor-General in Council may by order declare that the carrying of passengers between specified ports in Australia by British ships shall not be deemed engaging in the coasting trade. Underlying these provisions is the broad principle that all ships engaged in the coasting trade shall conform to Australian conditions as to manning, wages, and other matters. It is provided that no vessel shall engage in the coasting trade unless licensed to

do so. Such licences are for periods not exceeding three years, and it is specified on the licences that the seamen employed are to be paid wages in accordance with Australian conditions, as enacted, and that in the case of a foreign ship there are to be the same number of officers and seamen as would be required if she were a British ship, registered in Australia, or engaged in the foreign trade. No ship, whether British or foreign, which receives directly or indirectly a subsidy or bonus from a foreign Government can be licensed for the coasting trade. This provision will make it impossible for a vessel subsidized by a foreign Government to carry passengers, except on through tickets from port to port in the Commonwealth, or within territory subject to the Commonwealth. It is provided that the sections relating to the coasting trade shall also come into operation on a date to be fixed by proclamation, but shall not take effect on the date fixed for the commencement of the Act unless the proclamation fixing that date expressly declares so.

The total tonnage of oversea shipping entered and cleared the Commonwealth in 1911 was 9,985,000, which shows an increase of 1,162,000 tons, or 13·2 per cent., since the year 1907. The chief countries from and to which the shipping was entered and cleared are :—The United Kingdom (3,001,000 tons), New Zealand (1,886,000 tons), Germany (636,000 tons), Chile (576,000 tons), the United States (535,000 tons), South Africa (375,000 tons), Japan (261,000 tons), India and Ceylon (243,000 tons), and France (239,000 tons).

The shipping between the Commonwealth and the United Kingdom and European countries during the past five years shows that steady increase which indicates the consistent development of a well-established trade. The shipping in this direction during 1911 amounted to 4,213,000 tons, or 42·2 per cent. of the total oversea shipping of the Commonwealth, and was recorded against the several countries as follows :—United Kingdom, 3,001,000 tons (71·2 per cent.) ; Germany, 636,000 tons (15·0 per cent.) ; France, 239,000 tons (5·7 per cent.) ; Belgium, 187,000 tons (4·4 per cent.) ; other European countries, 150,000 tons (3·6 per cent.).*

The tonnage of shipping between the Commonwealth and New Zealand shows an expansion from 1,524,000 tons in 1907 to 1,886,000 tons in 1911, an increase of 362,000 tons, or 23·7 per cent., during the four years. The shipping with New Zealand represented 18·9 per cent. of the total shipping of the Commonwealth during 1911.

The total tonnage between the Commonwealth and Eastern countries during 1911 amounted to 1,822,000 tons, or 18·2 per cent. of the whole, representing an increase of 137,000 tons, or 8·1 per cent., as compared with 1907. The tonnage between Australia and China, Singapore, and Hong Kong collectively fell, largely in consequence of smaller exports of coal, from 413,000 tons in 1907 to 267,000 tons in 1911, while Japan increased by 15,000 tons (6·1 per cent.) The tonnage recorded as to and from India and Ceylon rose from 199,000 tons in 1907 to 243,000 tons in 1911. This tonnage, which is much

* The records appear to show that while the tonnage between the Commonwealth and the United Kingdom increased by 820,000 tons, equal to an increase of 38·2 per cent the tonnage between the Commonwealth and European continental countries has increased by 354,000 tons, or by 41·3 per cent., or in other words that 70·1 per cent of the increase was credited to the United Kingdom and 29·9 to the latter countries. No real significance can, however, be attached to these figures, for in many instances it must be regarded as almost accidental whether tonnage be recorded against the United Kingdom or against Belgium, Germany, or France

below that of the previous year, does not, of course, include steamers to or from the United Kingdom or other countries calling at Colombo *en route*. The tonnage recorded as to and from the Philippines shows a rapid decline during the years 1909 and 1910, though some increase again appears in 1911. The shipping tonnage between Australia and the Philippines has also been affected largely by the coal trade, which has been latterly of much smaller dimensions than in 1907. Owing to the limitation of the records, the figures given in the tables do not represent the full volume of the shipping between the Commonwealth and the Philippines. In addition to the shipping recorded to the Philippine Islands the regular steam lines between the Commonwealth and Japan make Manila a regular port of call, and it is by these vessels that the general trade—apart from the coal trade—is chiefly carried. The whole of the shipping which was recorded as entering the Commonwealth during 1911 from the Philippines (57,000 tons) was, with the exception of 3,500 tons, in ballast, and of the 103,000 tons which was recorded as cleared for that country, 78,000 tons cleared from the coal port of Newcastle. The tonnage between the Commonwealth and Papua has increased rapidly, though consistently, during the past five years, the tonnage recorded between these two countries being 35,000 tons in 1907, and 150,000 tons in 1911. There has also been a marked expansion of the shipping to and from the Dutch East Indies during later years, the tonnage having increased from 44,000 in 1907 to 159,000 in 1911. The shipping with the South Sea Islands, too, shows an expanding trade.

The shipping tonnage recorded between the Commonwealth and African countries during 1911 amounted to 502,000 tons, an increase as compared with 1907 of 151,000 tons. Much of the trade between South Africa and Australia, however, is carried by steamers calling at ports in the former country on their voyages between the Commonwealth and the United Kingdom, and which are not shown in relation to African ports in the shipping returns. Shipping tonnage with African countries—mainly confined to Cape Colony, Natal, and Portuguese East Africa—rose from 566,000 tons in 1904, to 650,000 tons in 1905, but fell to 528,000 tons in 1906, to 351,000 tons in 1907, and to 226,000 tons in 1908, so that the figures for 1911 indicate a very material increase during recent years. These figures are, however, of no significance as an index of the transport requirements between the two countries, inasmuch as of the total tonnage passing between the two countries 395,000 tons were from Africa to Australia, with only 106,000 the other way. Moreover, of the 395,000 tons which entered the Commonwealth from Africa, 369,000 tons, or 93·2 per cent., were represented by vessels in ballast seeking freights from Australian ports.

The shipping of the Commonwealth with North and Central America during 1911 amounted to 728,000 tons (7·3 per cent. of the whole) representing as compared with 1907 a decline of 291,000 tons. The large tonnage between the Commonwealth and North America during 1907 was due to unusually heavy exports of coal to the United States. The 728,000 tons of shipping with North and Central America during 1911 were recorded against the several countries as follows :—United States, 535,000 tons (73·5 per cent.) ; Canada, 163,000 tons (22·4 per cent.) ; and Mexico, 30,000 tons (4·1 per cent.)

The shipping between the Commonwealth and South American countries during 1911—835,000 tons—was 37 per cent. greater than in 1909, though still less than in 1908. The shipping in this direction during 1911 was mainly engaged in the carriage of coal and wheat to Chile and Peru, and its decline as compared with the earlier years under review is due to the smaller export of coal. Of the total shipping tonnage between the Commonwealth and South America during 1911, 632,000 tons, or 75·7 per cent., is credited to the coal port of Newcastle. Of the South American countries, Chile is responsible for 576,000 tons (69·0 per cent.); Peru, 104,000 tons (12·4 per cent.); Argentine Republic, 62,000 tons (7·5 per cent.); Brazil, 46,000 tons (5·5 per cent.); Uruguay, 41,000 tons (4·9 per cent.); and Ecuador, 6,000 tons (0·7 per cent.).

An important fact, from its bearing on freight rates and its consequent possible effect on the coal trade of New South Wales with South America, is the absence of return freights from that country. Of the 354,000 tons of shipping which entered the Commonwealth from South America during 1911 only five vessels, totalling 13,000 tons, carried cargo.

8. Railways.

The first movement for the construction of railways in Australia took place in 1846, and in the course of the next six or seven years several private companies were promoted in Sydney and Melbourne for the purposes of building various short lines.

As difficulty was experienced by these companies in obtaining sufficient capital for undertakings which were considered by many to be of an experimental character, the Government, pushed on by the popular clamour for railways, either subscribed directly for a large share of the stock, or made loans, secured by mortgage. In some cases it also guaranteed interest or dividends to private investors. None of the early railways was undertaken without one or more of these forms of public support.

The companies thus fostered were not, however, generally successful. In New South Wales the work of construction of the Sydney to Liverpool line was only well under weigh when the discovery of gold caused a general exodus from the city, and the company found it impossible to secure sufficient labour to carry on the undertaking. Other lines, both in New South Wales and Victoria, shared a similar fate, with the result that the Government had to step in and complete the work. In Western Australia two trunk lines were built by private companies on the land-grant system. In that colony the sparse population prevented the use of public funds for railway work, and land was consequently granted to build these two lines, which ran from the metropolitan district, north and south, to Geraldton and Albany respectively. The former still remains in private hands, and is the only trunk line in Australia which is not run by the Government. The latter was acquired by the Government in 1896 at a price of £1,100,000. At the present time, out of a total mileage of 17,842 miles open for general traffic, only 944 miles are under private control.

The principle of Government ownership and control may therefore be regarded as the settled policy of the country. It may be said that the Governments have recognised the supreme importance of a railroad policy,

not only as an element in the industrial, but even in the political life of nations, and have felt that nothing short of complete ownership and direct management of the railroads would give them the power which, for national reasons, they must exert.

The early essays at public control were not satisfactory, in regard either to economical administration or traffic service. With a view to overcoming the troubles which arose, the control and administration of railways was placed in the hands of responsible Ministers, who appointed a general manager to operate the lines. This system, however, opened the way to abuse, and resulted in political favoritism. To remedy this evil the control of the railways has been delegated to Commissioners, appointed by the Governor in Council, under statutory authority. The last State to adopt this scheme was Tasmania, where the control, management, and maintenance of the Government railways were placed in the hands of a Commissioner in 1911. In each of the States of New South Wales and Victoria there are three Commissioners, but in the other States only one each. The number of Commissioners, however, chiefly affects convenience in administration, and does not affect the principle of independent management. Under this system the Minister for Railways simply directs legislation, and represents the Railway Department in Parliament. He has no authority to directly interfere in the management, though the Ministry as a body, as the executive representative of Parliament, can veto a Commissioner's policy. The Commissioners issue annual reports to the Minister, except in South Australia, where the Commissioner reports to Parliament. In some of the States the Commissioners both build and manage the lines, but in others railway construction is in the hands of the Public Works Department.

The progress made in opening up lines during the twenty years which followed the completion of the first line in 1855 was very slow. This was no doubt due partly to the difficulty of borrowing money at a reasonable rate of interest, owing to the depreciation of Australian securities in London, and partly to the sparseness of the population, which it was feared would not justify the necessary expenditure. In the vicinity of Sydney, also, the ranges of mountains in the districts near the coast had to be either traversed or pierced by tunnels, at a considerable expenditure of time and money, thus retarding the expansion of the railway systems which now have their starting point at that city. Since the year 1875, however, greater activity in the construction of railways has been manifested, and satisfactory progress has been made in all the States of the Commonwealth. The great era of railway building in Australia was in the years 1887 to 1889, when the average rate of construction was between 700 and 800 miles per annum. In the eastern, south-eastern, and southern parts of Australia there now exists a considerable network of railway lines converging from the various agricultural, pastoral, and mining districts towards the principal ports, which are themselves connected by systems of lines running roughly parallel to the coast. These are shown on the accompanying map.* In the east, lines radiating from Townsville, Rockhampton, Brisbane, and Sydney extend inland in various directions for distances ranging up to over 600 miles; in the south-east there are numerous lines, those in Victoria converging towards

* See map on page 461.

Melbourne, while others in New South Wales have their terminus in Sydney; in the south there are three main lines, with numerous branches, running from Melbourne, while from Adelaide one main line, with several branches to the coastal towns, runs inland in a northerly direction for a distance of nearly 700 miles, and another line runs in a south-easterly direction to various ports, meeting the main line from Melbourne on the border of South Australia and Victoria. In addition to these main lines and their numerous branches, there are extensive suburban systems in Melbourne and some of the other cities of Australia, a considerable portion of the suburban traffic in Sydney being conducted by means of electric tramways. All these lines which have just been referred to are connected together by the main inter-State line, which permits of direct communication between the four capital cities—Brisbane, Sydney, Melbourne, and Adelaide—a distance from end to end of 1,790¼ miles. In Western Australia there is a connected system of main or trunk lines between the ports of the State and the agricultural, pastoral, and mining districts. From these main lines a number of branches has been constructed, opening up fresh agricultural areas to the ports and markets of the State. In the northern parts of Queensland and in the Northern Territory there are also a number of disconnected lines running inland from the more important ports. In Tasmania the principal towns are connected by a system of lines, and there are also, more especially in the western districts, several lines which have been constructed for the purpose of opening up mining districts.

The number of miles of Government and private lines open in each State for general traffic on the 30th June, 1912, was as follows :—

GOVERNMENT AND PRIVATE RAILWAYS.—MILEAGE OPEN FOR GENERAL TRAFFIC.

State.	State-owned Lines.	Private Lines available for General Traffic.
	Miles.	Miles.
New South Wales ..	3,832	141
Victoria ..	3,622	14
Queensland ..	4,266	346
South Australia	1,939	..
Western Australia	2,598	277
Tasmania ..	496	166
Northern Territory	145	.
Commonwealth	16,898	944

These lines are of no fewer than five different gauges, and, though not at present of any considerable magnitude, the extra cost, delay, and inconvenience incurred by the necessity of transferring through passengers and goods at places where there are breaks of gauge, are becoming more serious as the volume of business increases.

Although the cost of alteration to a uniform gauge would be great, many propositions have from time to time been put forward with the object of securing such a gauge, and attention has been drawn to the importance of the unification of gauges before further expenditure on railway construction is incurred by the States. The problem is, however, one which is by no means easy of solution, and the difficulties are increased by the introduction of what may be called questions of local or State policy. That its solution would facilitate the development of commerce and the settlement on the

land throughout the Commonwealth is now widely recognised. The economic disadvantages of breaks of gauge, and of any artificial restrictions in regard to trade finding its proper geographical outlets, are also seen by dispassionate observers. It is obvious, too, that in the event of a foreign invasion of any part of the seaboard, the interchange and concentrations of rolling-stock for the transport of men and war *matériel* would be impeded, and might result in confusion and loss. It is asserted, moreover, that unification of gauges would tend to reduce to a negligible quantity all tendency to disorganization and undue congestion likely to occur at times of bountiful seasons; that various trades and industries would be benefited by the aggregation, at times of abnormal or periodic activity, of idle trucks from other States; that there would be a large saving in the total capital expenditure on rolling-stock; in other words, that the fullest use of all rolling-stock and the meeting of all exigencies would be facilitated.

The question naturally arises as to which gauge should be adopted as the universal gauge of the Commonwealth. As regards Government railways only, the New South Wales gauge of 4 ft. 8½ in. has a mileage of 3,832; Victoria and South Australia have a combined mileage of 4,126 of 5 ft. 3 in. gauge; while Queensland, South Australia, Western Australia, and the Northern Territory have together 8,322 miles of 3 ft. 6 in. gauge. By far the greater part of the mileage of private railways open for general traffic has also been constructed to the 3 ft. 6 in. gauge. The mere question of preponderance of mileage, therefore, indicates the 3 ft. 6 in. gauge for adoption. But this question is obviously subordinate to those involving engineering and economic considerations. Thus, the relative efficiency from the widest point of view, the relative costs of alterations of permanent way and rolling-stock, of carrying capacity and speed, that is to say, questions of a technical nature, about which figures are not available, enter into the grounds for decision. As regards the unification of the New South Wales and Victorian lines, the advantage of reducing the broad gauge to the 4 ft. 8½ in. gauge is that there would be no necessity for the alteration of tunnels, cuttings, bridges, or viaducts.

Several conferences have been held from time to time, for the purpose of adopting a uniform gauge. The last of these was in April, 1913, when engineers representing the six States and the Federal Government recommended the adoption of the 4 ft. 8½ in. gauge as the standard gauge for Australia. The cost of conversion to that gauge of all lines on the continent was estimated at £37,164,000.

The necessary arrangements have now been completed for connecting the railways of the eastern and southern districts of Australia with the Western Australian lines by the construction of a line between Port Augusta, in South Australia, and Kalgoorlie, on the Western Australian gold-fields, a distance of 1,063 miles. The estimated cost of construction and equipment of the line is £3,988,000. It is claimed that the line would be of immense benefit in the expedition of the European mails to the southern and eastern parts of the continent, and, if occasion should arise, in facilitating the transport of troops. A Railway Construction Department has been created to carry out the work, and on the 14th September, 1912, the first sod of the Kalgoorlie-Port Augusta Railway was turned by the Governor-General at Port Augusta. A commencement has also been made at Kal-

goorlie, and it is estimated that the line, which is being built from both ends, and will have a gauge of 4 ft. 8½ in., will be completed in three years. In the Northern Territory Acceptance Act (under which the Northern Territory was transferred from the State of South Australia to the Commonwealth), the construction of a transcontinental line from South Australia is provided for: under that Act the property in the railways from Port Augusta to Oodnadatta, and from Darwin to Pine Creek, has been transferred to the Commonwealth Government as from the 1st January, 1911. The present Commonwealth Government has recently announced its intention of introducing the necessary legislation to proceed with the survey and construction of this line, which is said to present few engineering difficulties.

The total capital expenditure on the Government railways in Australia up to the 30th June, 1912, was £160,557,000, which gives an average cost of £9,502 per mile. This average is, however, unduly swollen by the heavy cost of some of the early lines, such, for example, as that from Melbourne to Bendigo, which was opened in 1862, at a cost of over £48,300 per mile. Many of the more recent lines have been built at an average cost of less than £1,500 per mile The gross revenue of the Government railways in 1912 was £19,101,000, which works out at £1,130 per average mile worked, or 7s. 9d. per train mile run. Nearly 57 per cent. of the gross revenue is derived from goods and live stock traffic receipts, 41 per cent. being from coaching traffic, and about 2 per cent. from miscellaneous sources. As regards coaching traffic, the receipts per passenger journey range from about 6d. in Victoria to over 1s. 9d. in Tasmania. The difference in these amounts is not accounted for by the rates charged, since the latter are fairly uniform in the several States, but is largely due to the different traffic conditions. Thus, the low cost per passenger journey in Victoria is accounted for by the large number of metropolitan suburban passengers in that State.

The total working expenses in 1911–12 amounted to £12,471,000, or 65·3 per cent. on the gross earnings. This percentage has increased since 1907–8 from 58·7 per cent., but the increase is stated to be due mainly to advances in salaries and wages of the staff and employés. The working expenses per average mile worked have increased from £583, in 1907–8, to £738, in 1911–12, while the expenses per train mile run have increased from 48·9 to 54·2 pence in the same period. The percentage of working expenses on gross revenue in 1911–12 ranged from 63·2 in Queensland, to 71·3 in Western Australia (and to 117·2 in the Northern Territory). In order, however, to make an adequate comparison of the working expenses of the Government railways in the several States, allowance should be made for the variation of gauges and of physical and traffic conditions, not only on the railways of the different States, but also on different portions of the same system. Where traffic is light, the percentage of working expenses is naturally greater than where traffic is heavy; and this is especially true in Australia, where ton-mile rates are in many cases based on a tapering principle—*i.e.*, a lower rate per ton-mile is charged upon merchandise from remote interior districts—and where on many of the lines there is but little backloading. Further, though efforts have been made from time to time to obtain a uniform system of accounts in the several States, the annual reports of the Commissioners do not yet comprise fully comparable data of railway expenditure. As an indication of the different traffic conditions

prevailing in the several States, it may be mentioned that the number of passenger journeys per mile of line worked in 1911–12 ranged from 3,409, in Tasmania, to 29,420, in Victoria, while the number of tons of goods and live stock carried per mile worked was lowest in Queensland (843), and highest in New South Wales (2,871).

The net revenue in 1911–12, after payment of working expenses, amounted to £6,630,000, or 4·1 per cent. on the capital expenditure. This gives an average of £392 per average mile worked, or 2s. 4¾d. per train mile run. The total amount of interest payable on railway loan expenditure in 1911–12 was £5,650,000. Deducting this amount from the gross profits, a net profit of £980,000 is left. This is equal to 0·6 per cent. on the total cost of construction and equipment. Though the average percentage of gross profits in 1911–12 was 4·1 per cent., an average does not accurately express the position. At an early period the need of constructing railways for the sole purpose of opening up undeveloped districts was recognised, and lines were built which could not possibly pay for some years to come: as these railways always preceded population, the money had to be raised at an almost speculative rate of interest, frequently amounting to 6 per cent., while the more recent loans have been effected at less than 4 per cent., hence the railways have been handicapped by a burdensome interest. At the present time, also, spur lines are constructed, which can scarcely be expected to instantly return revenue in excess of the expenditure, and so must, for a time at any rate, be a charge on the more developed branches of the railway systems, and tend to increase the ratio of working costs to revenue. It may be noted, however, that, although the loans made for expenditure on railway construction and equipment very largely increase the amount of the public debt of the Commonwealth, forming, in fact, more than half the total debt, the money borrowed has not been sunk in undertakings which give no return, but has been expended on works which are increasingly reproductive, yielding in most cases a direct return on the capital expended, and representing a greater value than their original cost. In Europe the national debts of various countries have been incurred principally through the expenses of prolonged wars, and the money has gone beyond recovery, but in Australia the expenditure is represented to a large extent by public works, which pay a direct return which is, on the whole, greater than the amount of interest due upon capital invested. In addition to the purely commercial aspect of the figures relating to the revenue and expenditure of the Commonwealth railways, it is of importance that the object with which many of the lines were constructed should be kept clearly in view; the anticipated advantage in building these lines has been the ultimate settlement of the country rather than the direct returns from the railways themselves, and the policy of the State Governments has been to use the railway systems of the Commonwealth for the development of the country's resources to the maximum extent consistent with the direct payment by the customers of the railways of the cost of working and interest charges. Further, the money has been spent in developing immense agricultural, pastoral, and mineral resources, which add to the wealth of the community, while the benefits conferred in providing a cheap and convenient mode of transit, and in generally furthering the trade and the best interests of the Commonwealth, are incalculable.

CHAPTER XII.

EDUCATIONAL POLICY AND DEVELOPMENT.

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SYNOPSIS.

A policy of centralization—how it arose, and developed.—Early history of education in New South Wales.—Comparison with England.—The failure of local effort.—Comparison with the United States.—The undenominational system and the religious difficulty.—The first stages of the evolution of Australian education.—The stage of reform and reconstruction.—Borrowing *versus* development.—The old system and the new: Difficulties of transition.—Subjects and methods.—Vocational training.—The new schemes of education in Victoria and New South Wales.—Technical education.—Co-ordination and the need for National Councils.—Education in outlying districts.—The status of the teacher.—Physical culture and medical inspection.—Moral and religious culture.—Australian Universities, comparative statistics.—The educational ladder and the broad highway.—The University in relation to schools, technical education, and labour.—Defects of a centralized system of education.

As contrasted with the highly organized systems of France and Germany, English education is said to be unsystematic, and American education uncentralized.* There may be certain advantages in an educational policy which leaves the future to take care of itself, but public opinion in Australia has long abandoned the faith in *laissez faire* as a suitable gospel for a nation in course of construction. Past history and present necessities point to a future development in which the two salient features will be *system* and *centralization*. Whether the combination of these two features is to produce a mechanical or an organic system will depend on the character of the people who live under the system. It is possible for a nation to be both politically free and politically organized. A people trained in habits of freedom will not submit to the tyranny of any bureaucratic rule until it ceases to do its thinking for itself. The bugbear of bureaucracy, like the spectre of socialism, is a favorite figure with journalists and politicians, but the Australian people, although like other democracies it has a fondness for phrases, takes political banners and battle cries with less seriousness than either the English or the American peoples. It carries still further the excellent English habit of treating proposals of social and political reform on their merits, as practical business measures for promoting the welfare of the nation. In the matter of education it has made up its mind that what it wants is system, and that centralization is the best way to get it.

In New Zealand, a homogeneous community is divided into provinces, whose history, physical divisions, and divergence of interests have led to the adoption of a decentralized educational system. Australia is a continent, and it is divided, not into provinces, but into self-governing States. While its population is, in all essentials, much more homogeneous than that of any other nation in the world, the enormous extent of its area and the variety of its economic interests will make the task of administration more and more complex as population increases. A "socialized" control of Australian education as a whole from a single administrative centre is outside the range

*Adams, *Evolution of Educational Theory*, p. 377

of practical politics at present, and, unless for those who fancy that national education can be "managed" on the analogy of a postal or railway service, is outside any profitable discussion of a possible future policy.

The unit of administration is then, and will continue to be, the State. Within each State the policy of centralization was not adopted as the result of a carefully thought-out plan. It rather forced itself on the public and on the legislature as the only way out of the many difficulties of the educational situation during the second and third quarters of the last century. These difficulties were partly economic in their nature, partly social and religious. The desire for a definite public policy arose in the breakdown of existing agencies to supply the needs of a rapidly-growing population. But there was never at any time in those early days any broad or scientific discussion of educational means or ends.

In the England of the same period, the problem of national education was treated with perhaps still greater disregard of the vital issues involved. In New South Wales, Mr. Robert Lowe, afterwards an English Minister of the Crown obtained in 1844 the appointment of a Select Committee to report on the actual state of education, and to devise means for the establishment of a system which would be in accordance with the needs and desires of the community. The report of that Committee contained, in principle, the scheme of later development. In the five years which were spent in overcoming the efforts to block progress, made by the opponents of a uniform and undenominational system of national education, Mr. Lowe probably learned lessons which afterwards influenced, and in ways that were in some respects harmful, the course of English legislation.

Three notes struck during the long controversy were repeated in England, and in the clamour raised over certain issues the educational aspects were obscured. The three notes were economic, political, and religious. The economic note appealed to those who saw waste and misdirection of energy through competition and overlapping in some districts, and absolute neglect in others. The pernicious system of payment by results was designed by Mr. Lowe's ill-directed business instincts, but was not imported into England from Australia, for, by a happy fortune, payment by results was never part of the educational policy of New South Wales, though at a later period it was adopted for a time by Victoria, with disastrous consequences. In a community where Ministers of Education are chosen as a rule not for any special educational qualification, it was more by good luck than by good guidance that Australia was saved from a policy which, wherever practised, has earned universal condemnation.

The political note may be expressed in the phrase which Mr. Lowe made popular in England, "Let us educate our masters." Australian legislation has, on the whole, been more uniformly progressive than corresponding English legislation. There have been "no leaps in the dark," and the consequent fear of what might happen when the educated ceased to correspond with the governing classes has never been so acute as in the older country, where the struggle between privilege and popular right roused so much passion and dread. Yet no democracy can afford to regard with indifference the existence of large numbers of uneducated citizens. In 1845, Mr. Lowe's

Committee reported that more than half the children of New South Wales (which then included the territories now known as Victoria and Queensland) were receiving no education at all.

The religious, or rather, ecclesiastical note, was sounded by those who were opposed to a merely secular education. The "religious difficulty" in Australia will be discussed later. Here, it need only be said that while credit may be given to the opponents of a common and undenominational school system for the strength of their conscientious conviction, they fought a losing battle from the first. Divergent ecclesiastical interests, the defective instruction provided in many of the private schools, and the insistent demand made for the subsidy of church schools from the common national purse, combined to hasten a new order which seemed predestined from the first, a school system which should be free, compulsory, and absolutely undenominational, and under centralized State control. This became the ideal towards which public opinion converged, and although in some respects the ideal is not yet fully realized, the issue was virtually fought and won in the years of controversy, which ended in 1848 (the year of European revolution) with the incorporation of the Board of National Education. The actual scheme which that Board attempted to carry out was no doubt unworkable from the first. It was a compromise which satisfied nobody at the beginning, and ended by irritating everyone. Demands were made on local aid which could not be fulfilled. As the Board, by its regulations, could not grant an application for a new school unless one-third of the cost of building and equipment were supplied by the applicants, education was neglected just in those districts where it was most needed. The principle of concurrent endowment of denominational schools was a source of continual jealousy, strife, and political and ecclesiastical engineering. The Board of National Education had to subsidize its own rivals without control over the expenditure of funds which it was compelled by Parliament to grant.

For eighteen years the unworkable scheme endured until it was replaced by the *Public School Act* 1867 of Sir Henry Parkes. Struggling with great difficulties, the Board of National Education had accomplished great things. At the end of its first year of administration it had only four schools under its direct control. At the end of its term of office it had brought into existence 259 National schools, with an attendance of 19,641 pupils. The strength of the opposition may be estimated by the fact that at the latter date (1867) there were in existence 310 denominational schools, subsidized by Government (without control), having an attendance of 47,627 pupils. The Board had to organize a workable scheme of studies, a system of classification, examination, and inspection, to devise means for the training of apprentice teachers, and to frame an adequate scale of remuneration for all teachers. The Board worked according to its lights. Judged from the business point of view, its efforts were praiseworthy and fairly successful. Judged from the politico-ecclesiastical point of view, its best work was, in the opinion of the majority, to demonstrate the failure of concurrent endowment. Judged from the educational point of view, as now understood, the result of the Board's work was to give a bad example to all Australia. This criticism is an historical, not a personal one. The period was one of dense ignorance, an ignorance unconscious of itself, on all but the superficial and

commonplace aspects of national education. A comparison of the English educational history of the same period would disclose the same ignorance of vital issues, the same short-sighted measures for patching defects, the same antiquated methods of training teachers, the same subordination of education to instruction in certain traditional subjects, the same formal and mechanical methods of examination and inspection. The "regulations," framed as a scheme *ad hoc*, to provide a convenient means of setting the educational house in order, soon acquired the authority and almost the sanctity of a traditional document. Teachers were examined later on the regulations as on a kind of Thirty-nine Articles. They were supposed to provide the full and fitting framework within which all future development would be carried on, and in fact they served as a model for the other States in their initial task of common school organization. Under the regulations it was the official who governed, and an analysis of the administrative system would reveal the real constitution. The secret of its strength and its weakness lay in the narrowness of the ideas behind it. The ideals set up were attainable without much difficulty. The Annual Reports were accepted as a proof that all that was wanted was an extension of the system on existing lines.

The Public Schools Act of 1867 contained certain inherent weaknesses which in course of time became patent. There was little or no dissatisfaction with the educational defects of the system, which had to wait, until the end of the century brought a wave of reform which shook the educational fabric in almost every State in Australia. It was only the working of the administrative machinery which, at the time, was felt to be defective. The provision that one-third of the cost of new school buildings should be contributed by the people of the locality could not, in a new country, be maintained for long without a corresponding increase of local responsibility and power of self-government. But Australia was already committed to a policy of central administration in almost every Department. The power of the politician had grown in the land, and any attempt at devolution of powers and responsibilities was resisted, not only by local districts, accustomed to draw on the national exchequer for almost every requirement, but by members of Parliament, who succeeded in blocking all attempts at establishing a system of local government for nearly half a century. Successive Governments were likewise unwilling to surrender the power over members which was derived from a lavish distribution of grants to districts, politically useful as a means of manipulating majorities, but injurious to public and parliamentary morality. The local obligation to contribute one-third of the cost of new buildings was abolished by the Act of 1880, due also to Sir Henry Parkes. Since 1880 the cost of new schools is defrayed directly by the Department of Public Instruction. Except for a few unimportant exceptions, the general policy of the Australian States in this respect is the same. The Department determines when, where, and how new schools should be erected, both in urban and rural districts. In many cases schools have been built with the slightest regard to what is required, structurally, hygienically, and educationally. School inspectors who, in addition to their ordinary duties, have often to act as clerks of works, are limited, as architects and officials are limited, by the economic necessities of the situation. It is difficult to gauge the requirements of a new and sparsely-settled district. Between the rapid growth of the city

population and the constant spread of the rural population, the Department authorities have to do, not what they desire, but what they can, with the limited means at their disposal. The result is that from almost every point of view the great majority of Australian schools are seriously defective. Only within the last few years has an intelligent care been taken to build new schools with due regard to what is required by the best modern standards. There is probably not a single school in Australia which could stand comparison with many admirably constructed and well-equipped public schools of England, Germany, Switzerland, and the United States. Here we touch one great defect of our system of centralized administration. It may be modified, if not removed, by greater parliamentary liberality and the development of public knowledge and public interest in educational matters. But when the special interest of the local district is not directly appealed to, it cannot be expected to show that pride and sense of responsibility which together have helped to produce the magnificent school buildings adorning even small cities in the United States. It may be useful in this connexion to refer to a common but misleading comparison made between Australia and the United States in the matter of expenditure on education. At first sight, the Australian State seems to suffer grievously from the comparison. Ten per cent. is a fair statement of the proportion of the total expenditure on education by the Australian State. The expenditure in an American State is often 50 per cent. of the total State expenditure, supplemented in many cases by an added 25 per cent. of the total expenditure of a local community. But this is only one of the many cases in which statistical comparisons have to be corrected by a wider knowledge of the political conditions of the countries compared. If the American State had to undertake the burdens of the Australian State, it could not afford the generous, sometimes lavish, expenditure on primary, technical, and university education. One burden alone may be mentioned from which the American State is entirely free, railway construction and maintenance. For better or worse, the Australian State has chosen to take upon its shoulders many burdens which are left in other countries to the initiative of individuals or private corporations. We need not discuss the wisdom of collective, as contrasted with private, enterprise in the task of social and political construction. Australia is a nation in course of rapid self construction, and with the lessons derived from the experience of other nations has deliberately chosen the more difficult, but perhaps wiser and more hopeful, method of nation building.

In the opinion of the writer the second inherent weakness of the Public Schools Act of 1867 was due to the provision for the continuance of State aid to denominational schools. This provision was a relic of earlier conditions. Had Australian Governments adopted from the beginning the principle of subsidizing local effort on a territorial, rather than on an ecclesiastical basis, the history of education in Australia might have been widely different. A decentralized system of the New Zealand type might have been the result. The other colonies followed the example of New South Wales. Taking warning from her history, they had not the same difficulties to encounter in dealing with denominational competition and ecclesiastical strife of tongues. New South Wales had by her own policy favoured the formation of a number of interests whose

energetic resistance was overcome only after an agitation which embittered political life for more than a generation, and culminated in the abolition of all State aid to denominational schools. Since 1882 the altered policy has been strictly adhered to, but recently a small departure, viewed with much misgiving, has been made from the principle which forbids financial aid to schools under ecclesiastical control. By the provisions of the *Bursary Endowment Act* 1912 State bursaries, providing for a continued secondary education, may be held at such schools. One main reason for granting this concession was the limited number of State secondary schools. To some the concession seems equitable; by others it is regarded as a dangerous return to a vicious principle.

The Public Instruction Act of 1880 is of great importance in the history of education in Australia, since in all essentials it helped to determine the nature of the educational system developed for the next quarter of a century. The controversy which produced it had its echoes in all the other colonies (as they were then called), and the principles underlying the Act had either already become, or soon afterwards became, part of the "common consciousness" of Parliament, press, and people. Those principles may be summarized thus.—The teacher became a civil servant; the school became State property; control meant State control under a responsible Minister; the schools were secularized, religion, when introduced, being taught in an undenominational form. The corollary, of course, was that the maintenance of the schools and the further development of the system should be a direct charge on the national exchequer. These principles have been embodied in the systems adopted in all the Australian States, although in Queensland local support and partial control still remain in connexion with the ten District Grammar Schools of that State. Many of the old questions which excited public controversy are now dead. Even if the ideal of a national system which shall be free, secular, and compulsory has not been fully attained in any State, it expresses the will of the nation. Primary instruction was not made free in New South Wales until 1906. High School fees were not abolished until 1911. The fee previously paid in the primary schools was 3d. a week, but exemptions were granted with great liberality. In the other States, fees varied from 3d. to 6d. weekly, although in some cases (*e.g.*, Queensland) as much as 1s. 6d. was charged in the higher grades. Primary education is now free in every State in Australia, the last vestige of school fees being abolished in Tasmania in 1908. The abolition of the fee system was hastened as soon as the Labour party began to make itself felt as a new power in political life.

Compulsory education, in so far as primary instruction is concerned, is accepted in principle, but in many cases is far from being fully carried out in practice. Western Australia has the highest average attendance in proportion to enrolment; New South Wales, the oldest State, has the lowest. In Victoria, Queensland, Tasmania, and Western Australia, attendance is required on every day on which the school is open. In New South Wales and South Australia attendance is required for only 140 days in the year. New South Wales makes the least satisfactory provision for securing regular attendance. The Act is defective and badly administered, with the results which might be expected. Western Australia has a stringent Act which is

rigorously applied. Victoria has improved its position in recent years, and compares favorably with New South Wales, but is still, like all the other States, defective when compared with Western Australia, which in this matter, as in several others, has shown an example of highly efficient administration. It is to be noted that throughout Australia the increase in average attendance does not keep pace with the natural increase of the population of school age. It is possible to exaggerate the defects of administration where the population is sparsely distributed over an enormous area, and when a large "shifting" element exists both in town and country. A fair test of the work which has been accomplished in primary education may be made by comparing the percentages at successive periods of children of school age, able both to read and write. In 1861 only 47 per cent. of such children could both read and write, while 25 per cent. were illiterate. In 1911 the former percentage had increased to over 90 per cent., while the totally illiterate had decreased by nearly two-thirds. Another test is supplied by the statistics for illiteracy, as shown by marriage signatures. In 1861, 24·60 represented the proportion of persons signing with marks to total number married. From that date, this significantly high proportion steadily decreases, until in 1911 it amounts to only 0·55.

In England, until the recent educational renaissance, the field of public interest was mainly occupied by the strife of ecclesiastical politics. The "educational question" when it appeared in newspapers meant the "religious difficulty." In Australia, after the storm and stress of early controversy, the settled national policy became one of non-sectarian instruction in all public schools. It seems unlikely there will be any departure from this policy, which was adopted as the natural and inevitable outcome of the conditions of Australian life and citizenship. It is difficult, however, to ascertain the exact state of the public mind as to the amount and quality of the religious instruction to be given in the public schools. Efforts are made at intervals, gradually becoming longer, by representatives of the various religious denominations to excite public opinion on the subject. The general indifference on a question which has been settled by the logic of events has been interpreted mistakenly as an indifference to religion itself. It may be true that there is, as asserted, a "growing recognition that a purely secular education is nationally unsatisfactory," but at the same time the majority hold a settled conviction that no return should be made to the former system. This was shown by a referendum, taken in 1904, in Victoria, the State in which the principle of purely secular instruction is most closely adhered to in the public schools. In spite of a most vigorous campaign to induce the people of Victoria to vote for a slight alteration, there was a decided majority against any interference with the established practice. In South Australia a portion of Scripture may be read in school by the teacher, if the parents so desire, but the reading must be "without note or comment." In the other States provision is made for religious instruction within school hours by the regular teacher, but it is difficult, from the references made to the subject in the inspectors' reports, to pronounce on the quantity and quality of the *formal* religious instruction given. In some cases (*e.g.*, Tasmania) the main emphasis is placed on Scripture history and geography. In New South Wales and also in Queensland and Western Australia, the range of formal

instruction is broader. The formal religious instruction, as given in the public schools of New South Wales, represents perhaps the utmost limit which can be conceded without turning teachers into exponents of special doctrines of religious faith. The various Protestant denominations have expressed their satisfaction with the existing system, and make only a limited use of the permission granted to clergymen to give special religious instruction in the public schools during regular school hours. In New South Wales one hour is allotted, in Victoria half-an-hour, to religious instruction given within the school by persons other than the official teachers. It need hardly be added that in no case is a pupil compelled to attend such special religious instruction given by representatives of particular forms of faith. The state of the public mind on the subject in general seems to be as follows:—With general recognition of the importance of religion as an element in national life, the warnings of the past, both in Australia and in other countries, are accepted as a salutary lesson for the future. Refusal of all State recognition to particular forms of belief is the silent or out-spoken witness which *de facto* and *de jure* forbids any attempt at reactionary legislation. The belief in division of labour in things spiritual, as in things temporal, leaves to the church and the parents the duty of providing for what is not the business of the secular authorities, doctrinal instruction in matters of religious faith. The Roman Catholic church, however, does not believe in the separation in the education of the young of the spiritual and the secular. It denies that in the absence of definite dogmatic teaching a residuum of undenominational belief can be retained, sufficient to supply the sanctions which are necessary for public morality, more especially for the morality of the young. To the Catholic authorities a system of education forms one whole, the elements not being separable. The position of the Roman Catholic authorities is a simple and logical one, and in face of the State's action they feel compelled to adopt a *non possumus* attitude. The only reply of the State is a similar *non possumus*. There can be no compromise between ideals which are so opposed in theory and in practice. In the presence of the *impasse* thus created, public opinion in Australia and the Roman Catholic authorities adopt opposite and apparently irreconcilable alternatives. The State, with its traditions of freedom and non-interference, allows the Roman Catholic church, or any other religious body, to conduct schools in which children may be educated according to the wishes of the parents. For the good of the community it establishes public schools at the common cost. For the good of the whole it may insist, and does insist in some States, on the registration of non-State schools and teachers, and on the inspection of non-State schools, so far as secular instruction is concerned. But there is no indication that the States will advance a step beyond these limits. It is only in the absence of a fully organized public secondary school system that certain concessions have been made by granting a limited number of bursaries tenable at non-State secondary schools, and it does not seem probable that such concessions will be extended in the future. On the other hand, the Roman Catholic authorities decline to modify their attitude. So far as their own schools are concerned, they maintain the policy of no surrender, and strive with great and praiseworthy energy to increase the number of their schools, to improve their methods of teaching, and ensure the pedagogic training of the teachers. But, in recent years, in sympathy

with a corresponding movement in the United States of America, the Roman Catholic authorities in Australia have vigorously re-asserted their claim to State subsidy on the grounds of public equity and what they denounce as unfair taxation. Roman Catholic citizens are taxed for an education system in the advantages of which they cannot share, and have, in consequence, to tax themselves a second time for the support of their own separatist schools.

Before dealing with this argument, it may be noted that the alleged general dissatisfaction with the public school system is not borne out by statistics of school attendance. During the period 1901–1911 the increased average attendance at private schools of all classes throughout the Commonwealth has not in a single year been as much as 3,000. The *increase* in the average attendance in the public schools of the Commonwealth during the same period has been 113,000, a figure only 19,000 behind the *total* average attendance at all private schools in the Commonwealth in 1911.

Among private schools it is probably only the Roman Catholic which are permanently maintaining an increase in the number of pupils in attendance. In New South Wales, where the separatist policy of the Roman Catholic church has been most vigorously pursued, the percentage of Catholic children attending the public schools compared with the total number of children in attendance fell from 11·18 to 10·98 (1901–11), a very slight decrease when the activity of the church propaganda is taken into account. The corresponding percentage of attendance at Roman Catholic schools rose during the same period from 15·15 to 16·30. It is estimated that, at present, for every 60 Roman Catholic children attending their own denominational schools, there are 40 attending the public schools. A fair proportion of Roman Catholics are employed as public school teachers, and a number of inspectors and higher officials of the Department of Public Instruction belong to the Roman Catholic church. Within the Departments the religious question has never been the cause of friction or serious embarrassment. Indeed, the social and political life of Australia is singularly free from the bigotry and intolerance which is unfortunately so common in some other countries. Anti-clericalism never raises its head except when an occasional aggressive note is sounded in some unguarded ecclesiastical allocution.

The demand for the State support of Roman Catholic schools on the ground of equity appears to the writer to be more specious than real. What no doubt is felt as a real grievance is the additional burden which the Roman Catholic parent has to shoulder for the privilege granted him of standing outside the national system. Like every citizen, he has to contribute to public services for the common good, in the advantages of which he will not directly participate. No body of individuals within the State can justly demand, simply on the ground of conscientious refusal to avail themselves of the common system, to be subsidized from the common purse for services which they undertake in religion, education, or any other sphere of public effort. It is only the size of the Roman Catholic minority which differentiates its claim in this respect from a similar claim on the part of any other section of the community which might make conscientious scruples a plea for public support. The Roman Catholic minority is not increasing relatively to the rest of the population.

During the last decennial period, the Presbyterian church population increased at a rate nearly twice, and the Church of England population at a rate nearly thrice, that of the Roman Catholic church. The total increase of the Roman Catholic population (1901–1911) was 70·805. The total increase of the "Christian" population during the same period was 647·965.

This religious difficulty is the only shadow on the fair prospect of Australian national education. Yet there need be little fear of a national policy which has become an integral part of the national consciousness being radically altered in principle, although it may be occasionally menaced by an accidental political combination, which would in all likelihood meet with swift and sure punishment at the polls. The position of the overwhelming majority who are opposed to the Roman Catholic demands may be briefly stated as follows:—The Roman Catholic education, by admission of the ecclesiastical authorities, is one and indivisible. The teachers in their schools are, for the greater number, clerical and unsalaried. In effect, to give grants of public money to Roman Catholic schools on the ground that they provide adequate secular instruction would be to subsidize a religious corporation and a body of clerical teachers at the expense of the majority, who disapprove, in varying degree, of State aid to religious corporations in any form, direct or indirect. The objection is not to the teaching of the Catholic doctrine, or to denominational education, but to a claim for privileged treatment. Such a claim not merely conflicts with the accepted national policy, but is disallowable on grounds of a deeper equity than the arithmetical and abstract equality of treatment demanded by the church in order to lighten the burden of a tax which is self-imposed.

The outward form of the organization of primary school education in Australia has now been described in broad outline. The space given to the educational history of New South Wales is due to the fact that, until the middle of the nineteenth century, the parent colony was almost identical with Australia, and that, after that date, the educational history of the other colonies followed parallel lines of development. The difficulties were the same, and were created by similar conditions. The remedies adopted were the same, half measures half-heartedly applied. From beginning to end there is a continuous and consistent evolution, both in principle and practice. Neglecting minor differences, due to variation in local conditions and mental outlook, the stages in the evolution may now be briefly summarized. In the earliest period of settlement education was left, in accordance with British tradition, to the parent or clergyman as a matter in which the State was not directly concerned. The Society for the Propagation of the Gospel in Foreign Parts deserves the credit of having taken the first step (1792) towards supplying schools and teachers. A church was turned into a school, four teachers were subsidized by the Society, and a clergyman was placed in control as superintendent. In Tasmania, as in New South Wales, the early schools were, for the most part, under direct control of the local authorities of the Church of England. Very soon, the other denominations took part in the task, and for many years the only education available was that supplied by the church schools, supplemented by a few private but generally inefficient institutions. In course of time, the necessity of organization was felt, partly on educational, partly on financial grounds.

The second stage was the appointment of Boards of Education, charged with the oversight and partial control of the existing schools, and the duty of extending the system In some cases there were two boards. Government and denominational. In such cases the conflict of interests soon produced friction. The interests of the various denominations were sufficiently alike to arouse common action. and Roman Catholics united with Anglicans and Nonconformists in order to secure as much government money as possible. The problem of distribution was settled on a simple arithmetical basis, and there was practically no government control over teachers, school buildings, or curriculum. In this stage, fitful attempts were made to stimulate local effort and responsibility, but for reasons already given the policy of centralization soon took entire possession of the field.

The third stage began by substituting for competitive boards single national councils (or their equivalents), which took over the greater number of denominational schools. This stage ended with the definite establishment of parliamentary control, under a Minister and Department of Public Instruction, and with the cessation of all State aid to private and denominational schools. Victoria was the first colony to inaugurate the new system in 1872. Acts to the same effect became operative in Queensland in 1875, and in South Australia in 1878. New South Wales, where delay was caused by the greater strength of opposing interests, followed in 1880. Tasmania did not come into line with development on the continent until 1893. Western Australia, after a long period of stagnation, developed in a very few years a national system of education which compares favorably with those of the older States, but it was not until 1893 that the Act of Public Instruction was passed, while aid to assisted schools was not abolished until 1895.

The fourth and present stage in the educational history of Australia is that of reform and reconstruction. Various amending Acts of Parliament have modified and enlarged the outward framework of the educational system, and great changes have been made in methods and aims, with a view to obtaining better results than were possible under the old stereotyped system of examination and inspection, borrowed from English procedure, and brought to a degree of mechanical completeness which fostered the illusion that we had "the best and best administered primary educational system in the world." The fact is that with the passing of the various Acts of Public Instruction. and (except for the Roman Catholics) the practical disappearance of the religious difficulty, the general impression was that the whole educational problem had been solved, and that all that remained was the labour of careful administration by competent officials. Judged by the prevailing standards, the system worked well. It was the standards which were at fault. Teachers, inspectors, and administrators were being transformed into self satisfied officials. Inspectors' reports were expurgated and edited, until they were reduced to a common level of dull official routine. The annual departmental reports conveyed no information and supplied no enlightenment on the real defects of the national system. As statistical documents they satisfied Parliament and the press. As educational reviews, their value was negligible. The public was, in the main, indifferent. It looked on subjects and methods of school instruction as things somehow ordained in Heaven and sanctified by use and wont. Parliament, the religious question

having been shelved, had not yet come to regard education as a political question at all. The teachers were subjected to a severe course of discipline, which made discussion of vital educational questions "disloyal" interference with the settled policy of the department. Above all, the men in charge of the administration had been trained within the system, and were apparently unable to grow beyond the system. Their minds moved within a closed circle. The pupil teacher system was made the sole avenue of admission to the service, which was guarded by a rigid Public Service Act from any intrusion of fresh blood. As a prominent politician put it, the service was suffering from in-breeding. According to the verdict of a foreign expert on education who visited the country, the "pupil teacher mind" dominated the system from top to bottom.

Various circumstances combined to disturb and finally destroy the general public and official satisfaction. The severest criticism came from within Australia itself, from a few voices crying in the educational desert. But such criticism might have been ineffectual if changes in economic and political conditions had not co-operated to rouse the public mind to the need for reform. There comes a time in the development of a young country when systematic and scientific organization must take the place of rough and ready happy-go-lucky methods of exploiting the national resources. Increasing differentiation of occupations brings a demand for increasing differentiation of training. The cosmopolitan struggle for trade makes each country a competing unit, and raises the standards of effective production and distribution. Protectionist policies indirectly contributed to force the question of the internal organization of economic supply and demand on public attention. The Labour Party began to shake itself free from its earlier narrowness of outlook, and with the responsibilities which came with greater power, showed a saner and more comprehensive appreciation of the problems of national education. No governments in Australia have been more ambitious in their educational aims, or more liberal in expenditure on national education, than the Labour governments which have been in power in New South Wales and South Australia. And in all the States, the Labour Party has been educated out of the old jealousy of higher schools and universities as exclusive and privileged institutions for the wealthier classes. It was probably the economic motive, more than any other, which induced the Legislatures to give a sympathetic hearing to the demand for educational reform. Individual and national "efficiency" was declared, in Australia as in England, to be the one thing needful. The public, which dearly loves a phrase, took up the cry. Politicians followed like hounds on the scent. The national system of education with its almost entire lack of co-ordination, was criticised in the press, the parliaments, and on platforms, with the same exaggeration with which it had been previously lauded. The most effective campaign originated in Victoria, where parliamentary neglect and inefficient administration had combined to block progress during the closing period of the last century. Victoria had been passing through a lengthened period of economic stress, as the aftermath of a succession of "booms," and a ruthless policy of retrenchment was applied in the department which could least afford it. In the last year of the century, a Royal Commission was appointed which laid bare the glaring defects of the existing administration. The first effect

was to educate the public mind to the need for radical reform in methods and organization. Later, a number of reforms were initiated, more particularly in connexion with the training of teachers, methods of school inspection, manual training in schools, and the preparatory steps for a system of technical education, varied according to local needs, and with special reference to agricultural industries. The period of economic stress in Victoria came to an end, but it cannot be said that Victorian education has progressed according to the hopes raised by the Report of the Royal Commission. Much of what has been accomplished is due in the first place to the courage and intelligence of the Chairman of the Commission, the Hon. Theodore Fink, and afterwards to the energy and enthusiasm of the present Director of Education. But nearly every educational reform in Victoria has been won after a long fight with forces of reaction and prejudice, and with the short-sighted policy which would limit free education to the meagre requirements of the traditional primary school subjects. The battle for the new education has, however, been fought and won at least in principle, and the only objections which are now valid are based on arguments which appeal to the pockets rather than to the hearts and heads of the people of Victoria.

In New South Wales, the resistance to reform on the part of the officials of the Department collapsed after a brief but lively period of public controversy. Throughout Australia the weakness of the *personnel* of the various departments became manifest when called upon to defend the system which had been built up with meticulous care for generations. One of the gravest defects of the old order appeared in the fact that although it abounded in excellent officials, it produced no men of striking personality, who left any impress on the educational life of the community. One exception should be made, in justice to the honoured memory of J. A. Hartley, who presided over South Australian education from 1876 until his lamented death in 1896. Western Australia owes much to the fortunate acquisition of Mr. Cyril Jackson (now of the London County Council), who for several years acted as head of the Education Department and inaugurated there a system which in some respects is still ahead of those of the Eastern States. Recent changes have brought to the front a number of men of high capacity, under whose guidance the various State systems of education are in process of rapid transformation. In New South Wales, a complete change was made in the higher ranks of the governing staff, following on the Report of the Commission of 1902. The Government had refused to grant the public demand for a Royal Commission of investigation, but appointed two Commissioners to travel for a year in other countries, and report on such improvements in education as might be found desirable. The general opinion of the authorities seemed to be that with a few "borrowings" here and there, the situation might be saved and criticism silenced. One of the Commissioners was an officer of the Department, the other was a University lecturer. The former, Mr. Turner, gave special attention to technical education, the latter, Mr. Knibbs (now Commonwealth Statistician), produced an encyclopædic report, which covered the whole educational field, and in effect led to the entire surrender of the policy of passive resistance on the part of the Minister of Public Instruction and the chiefs of the Department. In face of the educational débacle there could be no questions of half measures. The history of education in

New South Wales from that time to the present has been a record of consistent, and on the whole successful, attempts to construct a flexible, coherent, and comprehensive national system, which should correspond to the economic and political ideals of the people.

As usual, when reforming ideals take possession of a community, measures were advocated with a zeal not according to knowledge. The "faddists" rose to the occasion, and the public was bewildered by the number of fantastic schemes for bringing into existence an educational millennium. British sanity can generally be trusted when the question becomes one of practical construction. The whole history of educational development in Australia from the earliest beginning shows the application of ideas and methods which we share with the mother country. We have the same qualities and the same defects of the qualities. Sometimes we are a little ahead, sometimes a little behind, England in readiness to receive new ideas and to apply them systematically. But in the main, our educational development has taken place on British lines. The first settlers brought with them the English mind and temperament. The Australians of to-day are morally, intellectually, and politically in all essentials one with the parent stock. Over 95 per cent. of the population are of British birth or descent. Physical distance is discounted by the continuous and growing spiritual intercourse which exists between the two peoples. *Sidere mutato, mens eadem.*

If the "faddists" had been listened to, Australian educational reform would have been either a business of incongruous patchwork, or an importation of a system alien from the social and political character and ambitions of the Australian people. We were recommended to borrow this or that item from other systems, or else to adopt in its entirety this or that foreign system, for preference, French, German, or American. In face of the chaos of opinions, the reconstruction went on steadily on the lines of a development consistent with the actual national conditions. From the first, the organizers of the new system showed a sane consciousness of the difference between the things which could, and the things which could not, be borrowed. We may borrow, or rather imitate, certain ideals of foresight and forethought, scientific method, and thoroughness. We may learn from older countries the imperative necessity of special training for special functions, and in general the importance of systematic co-ordination of the various grades and departments of national education, hitherto left unattached in a traditional but perilous independence. Further, there are certain methods and schemes which we may borrow from other countries, where a similar economic situation has produced similar results.

There need be no hesitancy or confession of weakness in such borrowings. One salient instance is the problem of continuation schools. The first and thoroughly English attitude was to be content with instituting evening classes for the benefit of those who had failed to profit by the general education afforded in the primary schools. Tired day-school teachers repeated with the same method the same instruction to tired evening pupils. The changed economic conditions of modern civilization have made the continuation school problem one of vital national, and cosmopolitan interest. It is a problem in which a number of varying interests converge, very difficult to reconcile, the interests of parent, pupil, apprentice, workman, employer, trade-

unionist, and capitalist. No nation can afford to neglect experiments made by other nations, rivals, and possible antagonists in the cosmopolitan and competitive struggle.

At the same time, granting the necessity as well as the wisdom of a policy of borrowing from other nations in these and other important matters, the education of every community is carried on under certain definite social and political conditions which must be taken into account in constructing the frame work of the educational scheme, in determining the curriculum of studies, and the organic relation of the various grades of teachers and schools. In most of these respects, Australian social and political conditions are different from those of Germany or even England. A system of high schools, on the model of the great English public schools, would be an exotic in Australia, although we may "borrow" some of their ideals. More than half of the expenditure on English education was last year (1912) drawn from local rates. As compared with the Australian centralized system, with the State as unit for taxation and administrative purposes, there are in England at present 1,196 authorities of one kind or another, with varying powers of rating and controlling different grades of education. The gap between various classes of schools and teachers corresponds to English social distinctions which do not exist to anything like the same extent in Australia. Australians have no desire to see such distinctions intensified by an undemocratic organization of public schools. Germany, with its many lateral cleavages in the structure of society is a warning rather than an example to Australians. We decline to import any system which we believe would make for exclusive caste distinctions between schools, pupils, or teachers. The ideal of special training for special functions is not inconsistent with a unitary organic scheme of national education in which the democratic features of freedom of access to the highest positions, and freedom of promotion by merit and proved capacity, will be preserved and strengthened.

With all respect to the excellent work accomplished in the other Australian States, the existing scheme of organization in New South Wales represents the high-water mark of Australian educational endeavour. New South Wales has still some serious defects to remedy in regard to which she can afford to take lessons from other States, but, on the whole, her present system promises to fulfil what has already been defined as the requirement of an efficient national system of education, that it shall be flexible, coherent, and comprehensive. By the generosity of the Government of New South Wales, the Department of Public Instruction is being enabled to put the new scheme into effective operation. It only requires a continuance of that generosity for the system to be brought to full and beneficent fruition.

The total expenditure on education in New South Wales for 1912 (excluding technical and university education) was £1,572,000. Population (1911), 1,646,734. In justice to some of the other States, especially Victoria and Queensland, it should be stated that the reforming movement in those States coincided with the close of a period of financial stringency. The net cost per scholar in average attendance in the Commonwealth was £6 16s. 5d. in 1911, as compared with £4 9s. 3d. in 1901, a significant advance. The average cost per scholar in the various States in 1911 was :—New South Wales, £7 12s. 5d. ; Victoria, £6 9s. 11d. ; Queensland, £5 15s. 10d. ; South

Australia, £6 1s. 2d.: Western Australia, £8 6s. 10d.; Tasmania, £5 11s. 2d. The total expenditure on all forms of educative effort in the Commonwealth has increased from 13s. 4d. per head of the population in 1907–8 to 16s. 7d. per head in 1911–12.

It is impossible within the limits of this article to do more than sketch the general nature of the reformed system of education which, with certain necessary variations in detail, is now the common ideal in process of realization in all the Australian States. Rousseau, in his Emile, described in broad outline the modern programme of primary instruction. Emile was to be taught reading, writing, and arithmetic, singing and drawing, national history, orally and by narrative, and the principles of natural (undenominational) religion. Practical information was to be imparted by object lessons, and careful attention given to physical and technical training. Advances made during the last half century have been mainly in educational methods and in the surrender of the traditional teaching of subjects, as separate and independent, in favour of an organic scheme of instruction based upon certain central interests. The three R's ceased to be treated as ends in themselves, and became instruments of mental development. Correlated groups of subjects have been made the basis of classification, instead of single subjects, or the sum of separated subjects. Such a reformed scheme provides what did not exist before, rational centres of gravity for school work, and obviously implies a radical change in methods of teaching, classifying, examining, and inspecting. Within the limits laid down by general programmes of instruction, the freedom and independence of the teacher are encouraged and rewarded, instead of being discouraged and fettered as under the old system of formal examination of classes and pupils, with its dominating principle of testing for results which could be statistically expressed. The inspector ceased to be an examining machine. The teacher ceased to be a teaching machine. What was not sufficiently provided for in the first attempts at reform was (*a*) the necessary reconstruction of the curriculum by an appropriate grouping and co-ordination of subjects, and a clear exposition of the new educational aims and methods; (*b*) the difficulties attending a quick change from a system governed by use and wont and mechanical methods, to a system entailing a high degree of culture and spontaneous initiative. A great army of instructors cannot change their methods in a year in response to the summons of a Department. The key of the whole educational position lay as it always lies, in the training of the teacher. But this was just the part of the system which had been most neglected in the past. In only one or two of the States was there even a Training College, where some of the better qualified pupil teachers were enabled to remedy the defects of a primary school education, but received no professional training which deserves the name.

In the circumstances, three things were absolutely necessary—(1) The drawing up of a new programme of school instruction in accordance with the new ideals. This was done in the various States in different degrees of intelligence and completeness. Victoria was ahead of the other States in this respect, although Mr. Cyril Jackson had already done good work in the more limited field of Western Australia. (2) New methods of selecting and training future teachers. The pupil teacher system was doomed to disappear sooner or later. It had been maintained in existence so long mainly because

it was a cheap and easy means of obtaining a supply of raw material for the service. It is still maintained in a modified form in one or two States. In Victoria, where in the strife between economic and educational ideals the latter have generally suffered, the good intentions of the heads of the Department nave been partially frustrated by the lethargy of the State Parliament. The pupil teacher system still exists in Victoria, although shorn of its worst defects by the provision of High School training for candidates. A Training College (residential) in connexion with the University in great measure fulfils the demands of a professional training school. The Principal of the College is also Lecturer on Education at the Melbourne University, and both University and Department co-operate in raising the standard of scholastic requirements and the status of the teaching profession. Provision is also made for training secondary school teachers. In no other State has so much attention been given to the Summer School and other cognate means of assisting acting teachers to improve themselves in the technique of their profession. In South Australia for some years the training of the future teacher has been conducted by Adelaide University in co-operation with the Education Department. An efficient Training College exists at Perth, in Western Australia, and there is one, on a smaller scale, at Hobart, Tasmania. In Queensland the pupil teacher system has endured longer than elsewhere. but, with the recent establishment of the University of Brisbane, a new spirit has been roused in the northern State. The old examination *plus* drill system of training teachers will soon disappear, to be replaced by a system somewhat similar to that existing in South Australia. In New South Wales the pupil teacher has almost vanished from the land. Probationary students are selected by examination at a standard which presupposes a three years' course of education beyond the primary school. Successful candidates receive a free and assisted secondary and vocational training at High Schools. The ordinary course at the Teachers' College lasts two years, but a one-year course is also provided, qualifying for the third-class certificate. Third and fourth year courses are open to selected students. Supplementary evening courses are also provided for acting kindergarten and infant school teachers. It is hoped that the standard for entrance to the college will soon be made equivalent to a University matriculation. Qualified students receive free education at the University, and are encouraged to proceed to a degree. The Principal of the College is also University Professor of Education. The College has a staff of over 30 lecturers, the great majority being University graduates. To provide for the requirements of the smaller rural schools, a six months' course of training is given in a separate building. A course of training for secondary teachers is also provided, and the University gives a Diploma of Education to graduates. The College offers annually two travelling scholarships of the value of £200 each. The Sydney Teachers' College can stand comparison with the best similar institutions in Great Britain. One serious qualification must be made. The work of the College is carried on under most discouraging conditions. The buildings are quite unsuitable, limited in accommodation, deficient in equipment, and situated in one of the most insanitary districts of the city.

The third thing necessary was that Departments of Public Instruction should come to the aid of the great body of teachers in the difficult years of

transition from the old system to the new. In all the States, the inspectors were encouraged to sink the official examiner in the sympathetic co-operator. District classes were formed for demonstration lessons and discussion. Teachers were brought into closer intercourse with each other and with the officers of the Department, and generally a new educational and progressive spirit made itself manifest Full and detailed programmes of instruction with an abundance of illustration have been published by most of the Departments, but in no State with so much fullness and intelligent supervision as in Victoria In course of time much of this guidance will be unnecessary, but for some years it will be absolutely essential, and it is hoped that the educational authorities in the other States will imitate the excellent example given by the Victorian Department of Public Instruction.

In the reorganization of school work, special attention has been paid to the training of infant school teachers and the adoption of kindergarten methods. Kindergarten principles had been previously recognised as a matter mainly of book study. Under the old Departmental rule the foolish notion prevailed that all that was necessary in order to introduce new subjects or methods was to frame an official note or regulation. When public attention was called to some defect in the system, the Department replied with a few meagre instructions to teachers, and the reform was supposed to be accomplished. No adequate care was taken to provide trained instructors in the new subjects. Much of the kindergarten manual training and science teaching in the primary schools received, and deserved, the severest condemnation. The Free Kindergarten Union (first in New South Wales and afterwards in other States) established training schools and colleges for teachers, and their efforts and success stimulated the Departments to remedy the defects of the existing official system. In all the States considerable advance has been made in the lower grades of primary education by the elaboration of kindergarten and allied methods. In the teachers' colleges in Sydney and Melbourne much good original work has been done in child study, and in adapting methods which threatened to become stereotyped and mechanical to Australian conditions and the requirements of modern scientific psychology. In Sydney, both at the teachers' college and at the training college of the Free Kindergarten Union, the principles of the Montessori system are now being made the subject of experimental application by special teachers, some of whom have been trained at the Montessori institutions in Italy.

In manual training the old plan of employing an intelligent mechanic to teach the boys the use of tools was replaced in Victoria by the introduction of Sloyd methods under competent trained instructors, supervised by an instructor of manual training imported from England. In no other State does systematic manual training form so integral a part of school work. In science teaching Victoria again led the way by adopting improved methods of nature study as a preparation for more direct instruction in elementary science. In all the States science is taking a much more prominent place in the school curriculum than before, although development is delayed by meagre school requirements and lack of properly qualified teachers. The increased importance attached to the teaching of science in schools has been partly due to the public recognition of its close connexion with the progress of the national industries, and partly to the recognition of the pedagogic value of science as

an instrument of mental and moral training. We need, however, to be continually reminded of Huxley's warning that no teaching of science is worth anything as a mental discipline which is not based on a direct study of the facts and a practical exercise of the observing and logical faculties.

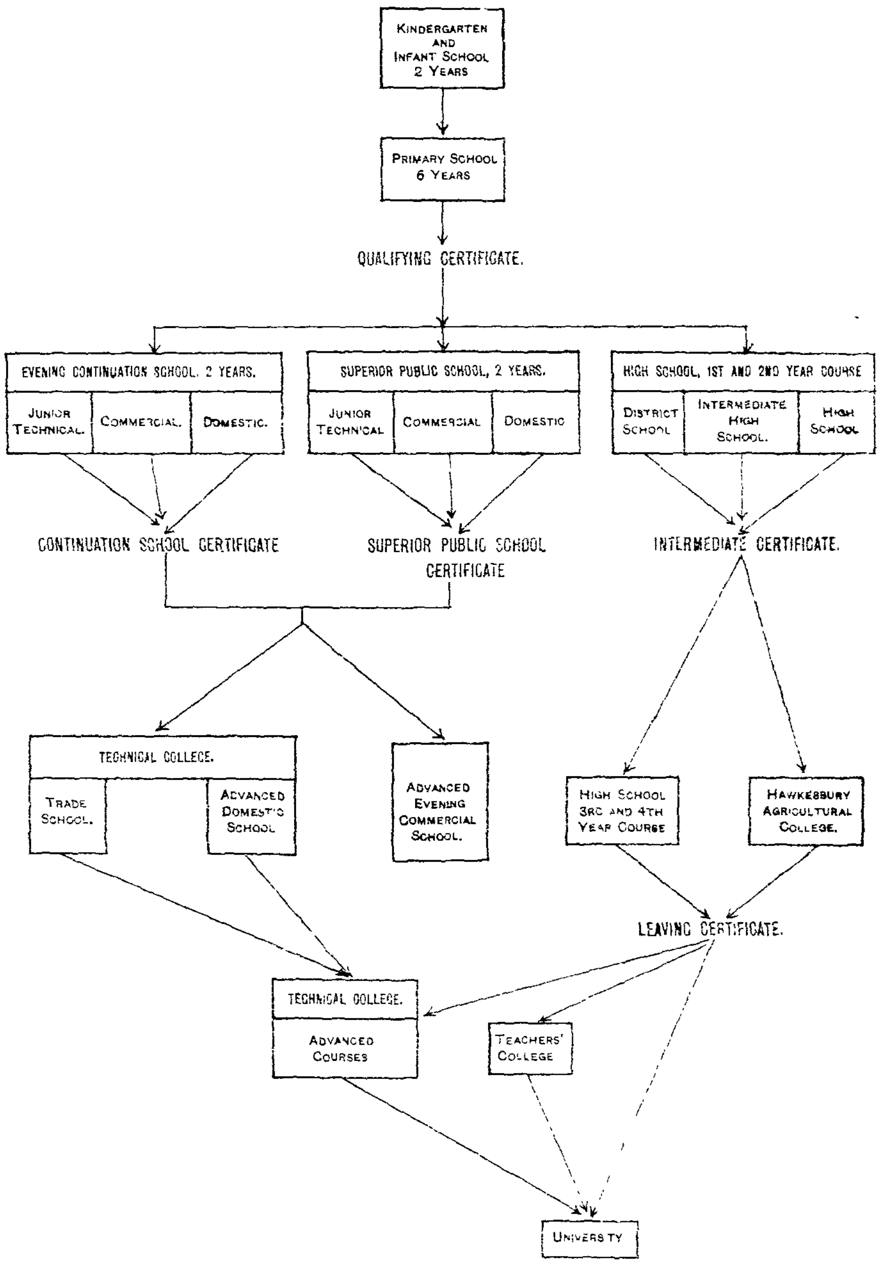
In reaction from the old formal training with its false division of the curriculum into separate subjects, treated independently, exaggerated emphasis has been laid on the necessity of "vocational" training. In the less (educationally) developed States, vocational training in the primary and superior schools has, for the greater part, taken the torm of an amateurish introduction of certain "occupations" as subjects of school study. But in all the States, the guiding principle is being recognised that unless in special schools the vocational must be subordinated to the educational end. The choice of subjects will no doubt be in part determined by the dominant local interests, but it is not enough that the school curriculum should reflect the environment. It is the task of the public school education to enlarge and enrich the spiritual environment of the pupil, and subjects and methods must not be such as to encourage a dangerous and premature narrowing of interests. At the same time, since the great majority of the pupils pass at once from the life of the primary school to the life of the field, factory, shop, or warehouse, the old formal training was obviously inadequate. The Victorian Commission on Technical Education (1909) wisely began its work, although to the surprise of the officials of the Department, by considering how far the primary school system was fitted to prepare the pupil for later specialized training and occupations. "The foundations of the work must necessarily be laid in the primary schools, and a wisely regulated course of primary instruction will do much to make the work of the technical school easy and to insure its success." The recommendations of the Victorian Commission have not been carried out in their entirety, but in Victoria and in all the other States, in varying degree, there is now in operation a scheme of instruction which provides for a reasonable amount of differentiation in the higher grades, and for later specialization in continuation schools.

In 1912 Victoria had nineteen district high schools of two types—high schools and agricultural high schools. A school farm of not less than 20 acres is attached to each agricultural high school. Pupils must be of at least twelve years of age, and must have passed the qualifying examination. No fees are charged to pupils under fourteen. In these schools there is during the first two years an industrial course leading to technical and trade occupations, and a common course for pupils intending to remain at school for four years. Both courses include English language and literature, history and civics, mathematics, geography, elementary science, drawing, manual work, and physical training. In the common course, a second language is optional—Latin, French, or German. Manual training includes woodwork and metal work, modelling, agriculture; and for girls, needlework and cooking. At the beginning of the third year, the general course of study is followed by special courses each extending over two years, and leading to the teaching profession, public service, commercial, agricultural, and higher technical pursuits, and to the University. The agricultural high schools are now well developed, and they provide an excellent training, both theoretical and practical.

In New South Wales the system is more extensive and complex, and the scheme, although still in the tentative experimental stage, is by far the most ambitious in Australia. The nature of the organization is shown in the accompanying chart. Under the previous system, a number of superior public schools (dating from 1880) provided a higher primary instruction. These are now in process of being reorganized into superior technical schools (32), superior junior or technical schools (21), and superior domestic schools for girls (52), the type of school being determined by local needs. In addition, 48 evening continuation schools have been established—31 in the metropolitan area, and 17 in country districts. Of these 22 are junior technical. 18 commercial, 7 domestic, and 1 preparatory. High schools, providing secondary education, have been increased in number from five to twelve. For admission to all these schools, a qualifying certificate is necessary, showing that the candidate has completed a full primary course. After a two years' course at any of the higher schools, qualified pupils may proceed to a further two years' course (16–18) at the high school, technical central college, advanced evening continuation schools, or Hawkesbury Agricultural College. Candidates who obtain the leaving certificate at the end of a four years' course may proceed to the University, teachers' college, or to advanced classes at the technical college. The principle of free education prevails throughout the greater part of this scheme, fees being charged only in the highest grades. Liberal provisions are made for bursaries and scholarships. In 1912, 300 State bursaries (£10—£30 yearly for two years) and 514 scholarships (free instruction and text books) were awarded. Intermediate technical scholarships (£25) were also awarded, entitling the holders to a free three years at the technical or agricultural colleges. Intermediate scholarships (50) were awarded, tenable for a further two years' high school course. Probationary student scholarships (88) enabled candidates for the teaching profession to complete the high school course. In 1912, there were 560 students attending the teachers' college, the greater number receiving allowances of various kinds. The total expenditure for such allowances was £18,620. The holders of scholarships receive free instruction and text books, and are granted allowances of £30 if living at home, £50 if living at a distance. Finally, 200 State exhibitions and scholarships are made available at the University.

The New South Wales scheme has been described in detail, as it shows the nature of the ideals and the correlated system which promise to prevail throughout the Commonwealth. In all the other States, the existing system is being modified and extended, but with less fullness of detail, and less liberal expenditure, than in New South Wales. The need for developing a State secondary school system has not been so strongly felt in some of the other States, where a number of efficient private secondary schools already existed. In Victoria, there is a large number of excellent denominational higher schools and colleges. In Queensland, there are ten district grammar schools (six boys', four girls') each of which receives a State subsidy of £1,000 a year, including £250 for the provision of district scholarships. In both States, these schools are subject to Government inspection. South Australia has nineteen district high schools (State) and at least two denominational grammar schools of the best type. Western Australia is establishing continuation classes and central schools, subsidizes one high school to the extent of £1,000 a year, and

Chart showing the General Scheme of Public Education in New South Wales.



has now in operation an admirably equipped modern school at Perth, with a four years' secondary course, providing both general and specialized instruction. Tasmania, owing to the financial loss entailed by her entering the Commonwealth, has been rather backward in educational development, but is now planning a scheme on lines somewhat similar to those adopted in New South Wales.

Certain weaknesses in the New South Wales scheme may now be noticed. Similar weaknesses are to be found in the other States, but, since the system of the mother State has received (for reasons mentioned) a prominent place in this article, they may now be stated with special reference to that State, the oldest and largest in the Commonwealth, which, after a lengthened period of educational stagnation, now claims to be in the forefront of modern scholastic progress.

1. The legal minimum school age is six years. The Australian child at that age has almost passed the kindergarten period. Although the number of children under six years attending State schools throughout the Commonwealth was, at last census, nearly 100,000, the corresponding number in the schools of New South Wales was under 10,000, and showed a tendency to decrease. No adequate provision is made for kindergarten instruction of these children in the State schools, and over 26,000 between the ages of five and six receive no school instruction of any kind. In these circumstances the free kindergartens are supplementing State effort, and the Government recognises the value of their work by an annual grant, £850 of which is devoted to kindergartens in Sydney. So long as children under six are practically excluded from State schools, the free kindergartens, which are entirely unsectarian, have a claim to support on educational grounds. Little children are often shockingly neglected in the poorer districts of the city, where, except for sporadic religious effort, the free kindergartens are the only civilizing agencies that exist.
2. The supply of properly trained teachers is not adequate to the demand. A full development of the new system is premature and dangerous until there is a fuller recognition of the principle of special training for special functions in the higher departments. Considerable improvement is noticeable in this respect. A generation ago, University graduates were practically excluded from the Public Service. There are now 264 graduates engaged in the various departments of State school work.
3. The proposed special trade schools exist at present only on paper, although one trade school, to cost over £6,000, is in course of erection.
4. Continuation schools are still in the experiment stage. The incongruous elements in the attendance (ages varying from 11 to 42), and the lack of special qualifications on the part of many of the teachers, are retarding development. Further, the absence of compulsion and the lack of public interest defeat the best efforts of the Department. The Australian boy or girl of fourteen has

not the slightest difficulty in obtaining employment for which no training is necessary. The most obvious requirement is that the State should regulate the employment of labour under the age of 16 or 17, so as to permit attendance at afternoon instead of evening classes. In this matter it is good economic, as well as good educational, policy to borrow from other communities, who, in similar conditions to our own, have been taught by experience the need of such compulsory legislation to protect children from the results of their own ignorance and from the selfishness of parents and employers.

5. The excellent principle, according to which the State should provide higher education only for those who show themselves capable of taking advantage of it, is not yet fully adopted in practice. From the junior technical school up to the technical college the work is hampered by the presence of many unqualified pupils. A more vigorous application of the tests for admission is necessary. But in the actual period of transition from an old system to a new many defects are unavoidable, which may be gradually eliminated in the course of development. If reasonable allowances are made, the present situation is full of hope for the future.

Technical education has been, until quite recently, in a chaotic condition, following the traditions and practice of the mother country. The Universities were not directly interested in it. The Education Departments for the most part thought their work accomplished, with the provision of a sound primary school education. Specialized technical instruction was left in the main to private effort. The first impulse towards improvement was due to the economic necessity of providing a better supply of skilled labour and trained directors of labour. The supply has never been equal to the demand, especially in the higher grades. Mining was among the first interests considered, and the Ballarat School of Mines, founded in 1870, occupies an honorable place in the history of technical education in Australia. The Sydney Technical College was not established until 22 years later, although long before that technical classes had been instituted in Sydney. Victoria has now four mining schools and a number of fairly successful technical schools and colleges. South Australia possesses one Central School of Mines and Industries, and five local mining schools of subordinate importance. The rapid progress of Tasmanian mining industry led to the establishment of the Zeehan School of Mines and Metallurgy, now affiliated to the University of Tasmania. The magnificent and varied natural resources of Queensland and the existence of a healthy district competition account for the special attention given in the northern State to technical training. Queensland has now sixteen technical colleges. Western Australia has one Central Technical School and about a dozen branch local institutions. In both Queensland and Western Australia, technical schools and colleges are now controlled by the State Departments of Education, and in both there is a special Director or Inspector of Technical Education. In the older States, only the slightest attempts were made for many years at co-ordination and control of technical training. Large institutions in Sydney and Melbourne were allowed to grow

into monstrous agglomerations of classes and studies. Since the end was a practical one, the "practical man" was usually allowed to dominate the situation. Sometimes the eternal struggle between the practical man ignorant of theory and the scientific man insufficiently acquainted with practice led to successive reversions of the controlling policy. The general result was confusion, cross purposes, and wasted opportunities. The more glaring faults have now been removed, or are in process of removal. In Victoria, the appointment of the Commission on Technical Education (1899) marked the beginning of a new era. The various technical schools, hitherto managed by local committees or councils and subsidized by the State, which had yet no effective voice in their control, are being taken over gradually by the Department, and a scheme of linkage is now being devised between the higher technical colleges and the district and agricultural high schools. Agricultural colleges and experiment farms (described in another article), controlled by the Department of Agriculture, exist in each of the States except Tasmania. The only comment that may be made concerning them in this article is, that the instructors appointed have often been men who, while practically experienced, had yet but a minimum of the scientific knowledge and training required. With the establishment of University schools of agriculture, this undesirable state of affairs will gradually be remedied.

The expenditure on technical education in Victoria has about doubled in the last six years. In Western Australia and New South Wales it has more than doubled within the same period. But the fact of such relative increases may convey a wrong impression of the general situation, for the total expenditure on technical education in the Commonwealth is still less than 1s. per head of the population, and compares very unfavorably with the amount (over 12s. per head of population) spent on primary education. Australia falls behind New Zealand in national expenditure on technical as well as secondary education. The Australian public has not yet been roused to anything like a full consciousness of its responsibilities, or of the proper place which technical education must take in the organization of the national system of education.

The traditional British policy of entrusting everything to local boards and councils has been a failure in Australia. The policy of subsidy without control has also failed. Many are of opinion that the new policy of co-ordination and control has not been carried far enough. The Victorian Commissioners advocated the appointment of a State Council of Education as a safeguard for the maintenance of educational progress. Such a body, it was argued, would not in any way lessen or interfere with Parliamentary control or Ministerial responsibility. "Its duty would be to study continuously all parts of the educational system, from the State school to the University, and to report on the reforms introduced in other countries in all departments of instruction." Such a council should contain representatives of all the educational interests in the State, and also representatives of all the leading economic interests, who should be "chosen, as far as possible, by reason of their experience and qualifications in dealing with educational problems." In New South Wales a similar proposal has been advocated from time to time, but public opinion remains indifferent on the question. Probably the evils of defective organization have not yet been sufficiently felt by the Australian

people, or by leaders of public opinion. In Victoria, a Council of Public Education has been recently called into existence by Parliamentary enactment. The functions of the Council are limited, but effective work has already been done especially in connexion with the registration of non-State teachers and the inspection of private schools. It is probable that the main reason for the appointment of the Council was the limited power allowed to the Department by the Legislature in the matter of secondary and higher education. In the other States, where the Departments of Public Instruction are not limited, the need for a National Council has not been so strongly felt as in Victoria, where powerful private and denominational interests had to be conciliated by the creation of a special Board, on which they should be directly represented. On the general question of the expediency of a National Council of Education, all that need be said is that except to a limited extent in Victoria, it does not seem to be within the range of immediate practical politics. It will have to wait until the growing complexity of educational development makes the problem of effective co-ordination more urgent than it is at present.

Before treating of University education, some notice may be taken of three important subjects—the provision made for the education of children in the more remote districts, the position of the Australian teacher, and the moral and physical training of the Australian pupil.

The Northern Territory (white population under 2,000) is administered by the Commonwealth, which also protects the interests of the aboriginal inhabitants. The Federal Government takes no share in education outside this limited sphere, except in the control of the Commonwealth Naval and Military colleges. In the various states, Native Protection Boards provide for the elementary education of aboriginal children. The educational needs of the white children in outlying districts led to the early establishment of provisional and subsidized schools, which have greatly increased in number. Sometimes, instead of opening several small new schools, the better plan, economically and educationally, is adopted of conveying the children to the school. Western Australia gives "driving grants" when parents live 3 miles from the nearest school, and supports over 250 schools, with an attendance in each of between ten and twenty children. The Queensland Department pays nearly £7,000 a year to itinerant teachers, and nearly £10,000 for provisional schools. The average cost of a pupil in a provisional school is greater by nearly £1 10s. than the cost of the education of a pupil in an ordinary State school. In Tasmania, New South Wales, and other States, the Department makes provision for teaching in localities where an average of ten cannot be secured, by subsidizing approved private teachers at a rate not exceeding £5 per pupil per annum. In 1912 the New South Wales Department spent over £17,000 in such subsidies. Arrangements are also made for conducting temporary schools at railway construction centres and on mining fields. It cannot be said that Australia fails in her duty to the children in remote and sparsely settled districts.

The position of a teacher in social and political estimation depends mainly on the social value attached to the work performed and on the quality and quantity of the prior training required. A plentiful supply of untrained teaching labour was in itself almost sufficient to account for the low rates of

remuneration which prevailed under previous conditions. When the public recognises that the work done is work worth paying for, and that the quality of that work is improving, it will be willing to pay teachers more liberally. But the ordinary parent, especially among the labouring classes, fails at present to see the intimate connexion between the boy's school work and the man's life work. It is not likely that the teacher's remuneration will ever correspond to the social value of his function. It hence becomes necessary that the State should aid him in two ways, by bearing part of the cost of the long preliminary training, and by providing a reasonable pension after a long life of honorable and arduous social service. Progress may be noted in both these respects. The duty of pensioning civil servants is at least admitted, excepting perhaps by the Melbourne press, but some of the superannuation schemes are very defective, badly devised, and inequitable in distribution. In all the States, greater aid is now given during the preliminary period of education and training, but in varying degree. New South Wales has the most complete and liberal system. Teachers in the service, who are qualified, are allowed to continue their education at the University, and to qualify for a degree in arts or science, without payment of fees. The salaries of teachers have been raised considerably in recent years, especially in the lower grades, but many qualified adult teachers still receive less pay than an ordinary mechanic or dock labourer. There are variations in the standard of remuneration in the different States owing to allowances for house rent, etc., but the limits for teachers in charge of schools are £110 and £120 for small rural and provisional schools, and £500 for heads of large schools. The corresponding limits for women teachers are £110 and £370. Male assistants receive from £65 (Tasmania) to £222 (New South Wales). Western Australia pays higher average rates than the other States, probably higher than any other country in the world, for similar service. Victoria has recently raised the salaries of her teachers, but the greatest increase in total expenditure on teachers' salaries has taken place in New South Wales. The public school teachers in that State increased in number (1902-1912) from 5,401 to 6,559, the average attendance from 155,916 to 167,752, the total amount paid in salaries and allowances from £644,961 to £1,027,907. Taking a shorter period, the total rate of increase on salaries paid to teachers between 1909 and 1912 has been 27 per cent. The greater part of this increase has been probably due to the desire, stimulated by Labour legislation, to raise the minimum living wage in the lower ranks of the teaching profession. The democratic jealousy of higher salaries for the highest positions is weakening, but it is not likely that school work will ever offer the prize positions which are common in other professions. Hence the necessity, incumbent on the State, to make wise provision, not only for security of tenure, but also for an equitable system of retiring allowances.

The physical culture of the Australian pupil receives more intelligent and systematic attention than is given in most other countries. It is, no doubt, aided by the freer life encouraged by Australian conditions. But in the city districts the playgrounds are restricted in area, and a "weedy" type is becoming common, in spite of the tendency to sports, a tendency which is much exaggerated in newspaper writing and travellers' tales. The cadet system, school drill, and the compulsory military training are moral as well as physical

influences for good. Much, however, remains to be done by opening children's playgrounds in city districts, and by an enlightened system of town planning. The congestion in some parts of the cities, and even in some suburbs, has given rise to open sores, which are indicative of past neglect. The municipal councils are generally composed of well-meaning business men, who are content with a policy sufficient for the day, but who rarely show wise and comprehensive foresight for the future. In Sydney, owing to its physical conditions and earlier foundation, municipal reform is involving enormous expenditure in requital for the sins of the past. The physical condition of the Australian children was assumed to be excellent until recent scientific investigation rudely dispelled public complacency. Tasmania claims to have been the first State to undertake an inquiry into the health of children attending State schools. Medical inspectors have now been appointed in all the States. They are assisted by specialists and nurses, and the Commonwealth Government is preparing a scheme of uniform investigation and classification. In Tasmania it has been found that, "speaking generally, the older and more isolated the settlement, the greater was the number of defects found in the children, and the lower the mortality." In the Hobart district, among 485 defective children (out of 2,108 examined), 174 were found to be suffering from imperfect vision or diseases of the eyes, 42 from diseases of the ear, 136 from marked adenoid growth, and 15 from pronounced curvature of the spine. (Report, 1912.) Queensland has a very thorough scheme of medical inspection in operation under competent officers. In Queensland, as in all the other States, dental troubles are found present to an extraordinary degree, especially among children of the city, while ophthalmia is a threatening evil in the remoter districts. Attention may be drawn to the excellent carrying out of the Queensland scheme of medical school inspection (for detailed description of results, cf. Annual Reports of Queensland Education Department, 1910–12). So far as the general investigation has gone, the results seem to show the same defects, and in somewhat the same proportion, which exist among the children of Europe and America. The disclosures will result, it is to be hoped, in greater attention being given to the physical conditions of school life. The efforts of both teachers and pupils are grievously handicapped by defective structural and hygienic school conditions. And what is wanted is not merely better school buildings and furniture, but more light, more air, and more soap.

The results of medical inspection have also given new importance to the necessity for special treatment of defective and backward children. In the teachers' colleges, the causes of retardation are being systematically studied, and the new psychology is coming to the help of those who are dissatisfied with the old rough and ready methods of classifying children *en bloc*. Hitherto State Governments have been content with establishing or subsidizing a few special institutions (not always under proper scientific educational supervision) for the more extreme cases of abnormal children. There is a widespread indifference to the fact that every school contains a certain number of children sufficiently abnormal to prevent them from being benefited by the ordinary methods of instruction. Such children are serious hindrances to the general instruction, besides suffering themselves from undetected and uncared-for physical and mental defect. No adequate provision has been made in any

State for the special treatment of such abnormal or partially abnormal school pupils, although in one or two instances (*e.g.*, in Victoria) some attention is being given to the training of selected teachers for special work. This is undoubtedly the necessary prior task before arrangements can be made for even the partial segregation of defective pupils in special classes or schools. The utmost that can be said at present of Australia is that the various Education Departments are only beginning to be dimly aware of a new field, which calls for urgent investigation and the adoption of new methods.

The moral education of the Australian youth has been unfavorably criticised by visitors, who find what they sometimes describe as a lack of reverence. This is, in most cases, a facile phrase for explaining to themselves an indefinable change in the social atmosphere as compared with that of older countries, where the rules of manners as well as of moral duty are imposed by tradition and secured by convention and habit. At any rate, the lack of reverence, if it exists in Australia, is a social characteristic not peculiar to the Australian school boy or girl. An Australian might himself prefer to describe it as a lack of servility, and a humorous disregard of social ritual and conventions, which do not appeal to his intelligence or his sense of utility. Judged by standards which are not merely subjective and individual impressions, Australian adult and juvenile morality compares favorably with that of other countries. Authorities agree in considering that a fair comparative test of criminality must be based on the number of commitals to higher courts, since the total returns from lower courts contain a large number of cases which are "merely technical breaches of laws having in some instances a purely local significance." Since 1861, there has been a steady decline in the number of commitals in proportion to population, from 22 to 6 commitals per 10,000 of the population, *i.e.*, a decline of about 73 per cent. The rate of convictions for serious crime in the Commonwealth has decreased from 69·3 per 10,000 persons in 1881 to 24·6 per 10,000 in 1911. The prison population of the Commonwealth has decreased from 16 per 10,000 in 1891 to 6·9 per 10,000 in 1911.

Much adverse criticism on the public school system seems to be based on the assumption that, since dogmatic or sectarian religious instruction is not given, the morality of the public school pupil must therefore be lower than that of the pupils attending denominational schools. No satisfactory proof of this sweeping a priori judgment has ever been given. As in other countries, the better private schools and colleges contain a large proportion of pupils who come from homes where the standards of refinement are above the average. The difference between pupils in such institutions and the majority of State school children is a social, rather than a moral, one, and gives rise to much confusion of judgment. Those predisposed to attach great importance to formal religious instruction in schools naturally claim for such instruction the credit of much that, in the opinion of others, is really due to the ordinary healthy life of the home and the school.

The absence of religious instruction of a formal and dogmatic kind from the State schools does not necessarily imply the absence of a moral and religious spirit. The exposition of doctrine is technical, not moral or religious, and there is great difference of opinion as to the educative value (moral or

intellectual) of much that is included under formal religious instruction. Mr. H. G Wells, turning his attention for a moment from schemes of economic and materialistic reconstruction, finds occasion to say that the young particularly need to be taught "truthfully and fully all we know of three fundamental things, the first of which is God, the next their duty towards their neighbour, and the third, sex. The adequate *why* of these, and some sort of adequate *how*, make all that matters in education." Australian educators are not peculiar in neglecting the importance of instruction in sexual physiology and psychology, and, so long as the public mind is dominated by the policy of absolute reticence, the neglect must apparently remain. The best way of introducing the subject in school instruction would perhaps be by collective lessons on the lines advocated by the White Cross League. In religion, even if dogmatic and sectarian instruction is to be excluded, much is left to the teacher, provided he is a person of serious and high convictions. Here again, the key to the educational situation is to be found in the training of the teacher, in the production of the true educator, who becomes a moral and spiritual force in the living community which is the school, and not the mere purveyor of certain pabulum of instruction. "Their duty towards their neighbour" means, if it means anything beyond the commandments and the conventions, a training in civic duty which begins with the life of the school, in initiation into Goethe's Three Reverences, reverence for our fellows and equals, reverence for those who are wiser and better, and reverence for those who are weaker and younger than ourselves. In all the Australian States probably more attention is paid in State school teaching to civics, and the principles of a sound social morality, than in the non-State schools, where these subjects are either neglected or lost sight of in the attention given to ritual, or formal religious instruction. In all the programmes of State school education, an important place is reserved for systematic instruction in the principles of morality and good citizenship by means of text books and carefully prepared schemes of lessons. The conception of the true function of the State school as a moral and educational instrument may be best stated in words quoted from the regulations with regard to inspection and examination, issued by the Victorian Department of Education. "Although as a general rule, the efficiency of the instruction will be measured by the inspector's tests, and by the number of pupils who pass the qualifying examination, or who gain the certificate of merit, or a scholarship, it should be clearly understood by teachers that the inspector's opinion of the worth of the school to the community will outweigh the results of examinations. The worth of the school to the community consists in the work it does in quickening the mental life of the pupils, in forming habits likely to result in worthy character, and in inducing its pupils to pass on to a higher type of school, or, before they leave the elementary school, to complete the full course. More important than successful acquisition of knowledge as revealed by examinations is an affirmative answer to such questions as these :—Are the teachers faithful and zealous in their work, and are the pupils being systematically practised in earnest, honest endeavour ? Are they being trained to think, to think quickly, and to think for themselves ? Are they interested in what they are doing, and are they being taught to apply it in their out-of-school affairs? Is their school environment calculated to produce a cheerful performance of their duties, a

consideration and respect for the rights of others, and an ideal of honour and truthfulness in word and act ?"

University education in Australia has followed the lines of British development. The State Universities of to-day resemble in many respects the great English provincial Universities of Manchester and Birmingham. The degrees are, by Royal Letters Patent, declared of equal status with those of any other University in the Empire. There are no tests of any kind, save those of merit and capacity. They are secular, in so far as no instruction in theology is given or theological degrees granted. Women students are admitted, and can proceed to degrees. They are all national Universities, in great measure supported by Parliamentary grants, and the State is represented, directly and indirectly, on the governing councils.

The six Australian Universities vary considerably in size, financial endowment, and complexity of organization. Sydney (founded 1850) and Melbourne (1853) are the oldest and largest. In the years in which these Universities began operations, the respective State populations were only 266,900 and 347,307. When the University of South Australia began work in 1876 the State population was slightly over 210,000. The estimated population of Tasmania in 1890, when the University was founded, was only 144,787. The two remaining Universities were not founded until within the last year or two. Queensland University was formally opened in 1911; State population, 622,129. The University of Western Australia began work a year later; State population (1911), 294,181. The delay in the establishment of Universities in the northern and western States was due in the latter case to slow national development (the population of Western Australia in 1890 was still under 50,000); in the former case, to a prolonged period of financial depression.

The number of students attending lectures at the various Universities (comparative estimate for 1911) was—Sydney, 1,407; Melbourne, 1,129; Adelaide, 621; Tasmania, 147; Queensland (opening year), 83. The figures for Melbourne and Adelaide do not include students in music. The University revenues were estimated in 1911 as follows:—Sydney, £69,557 (including Government grants, £22,550); Melbourne, £67,051 (grants, £28,190); Tasmania, £6,930 (grant, £4,500). The new University of Western Australia is to receive from Government an annual grant of £13,500.

Private benefactions also vary in amount. Sydney University has received benefactions of a capital value of over half-a-million pounds. Melbourne University has received over £160,000, and Adelaide nearly as much. The University of Tasmania has practically no private endowment. Sydney University library contains 100,000 volumes and 700 serial publications. The opposite extreme is found in Tasmania, where the local University library contains only 1,800 volumes and 12 serials.

The organization of the Universities is on familiar British lines. The governing body is a small senate or council, with over twenty members. A general council (corresponding to convocation) is, in the older Universities, composed of graduates only, but in the new Universities of Queensland and Western Australia it contains representatives of the national, industrial, commercial, and scientific interests, and also donors of sums over £100. The general council in some cases has only a deliberative function, in others it

has powers of revising University legislation. In the constitution of Sydney University, the University is declared to consist as a corporation of the senate. The wider point of view appears in the constitution of the University of Queensland, which is declared to be "a body corporate consisting of senate, council, and graduate and undergraduate members."

The range of studies also follows British precedents, with the addition of subjects recognised in American Universities and in some of the newer British Universities as fit and proper subjects for University instruction. The most complete curriculum exists in operation at Sydney and Melbourne. Melbourne University has eight faculties—arts, law, medicine, science, engineering, agriculture, dentistry, veterinary science (and also a musical examination board)—with a staff of eighteen professors and over 60 lecturers, as well as a large number of teachers of music. Sydney has four faculties—arts, law, medicine, and science—with departments of mechanical and electrical engineering, mining engineering, and metallurgy, economics and commerce, agriculture, veterinary science, dentistry, and military science. The Sydney University staff consists of 22 professors and over 100 lecturers. Adelaide University gives instruction and grants degrees in arts, law, medicine, science, English, and music. It has also a faculty of commerce, a department of education, and a conservatorium of music. It has a staff of eleven professors and 30 lecturers, not including teachers of music. The University of Tasmania has four professors and seven lecturers in three faculties of letters, science, and law. The new Universities of Queensland and Western Australia began with a limited programme, in which the emphasis was laid on "utilitarian" rather than on "culture" subjects. But within a year the programme was expanded, and it is probable that both the new Universities will repeat the history of Birmingham University, where the liberal studies, at first subordinated, were quickly developed into a fully organized faculty of arts. The University of Queensland began (in 1910) by establishing four chairs—classics, engineering, chemistry, and mathematics and physics. It has now (1913) a faculty of arts with two professors and ten lecturers, a faculty of science with one professor and nine lecturers, a faculty of engineering, with one professor and three lecturers. The University of Western Australia began with four professorships—modern literature and history, mathematics and physics, chemistry, and engineering and mining—but has now made additional provision for the teaching of classics, philosophy, economics, geology, biology, agriculture, and other subjects.

Most of the professorships are held by graduates of English and Scottish Universities, but a considerable number of the professors and the great majority of the members of the junior staffs are Australian graduates. Many Australian graduates have afterwards obtained distinction at English, German, and American Universities as post-graduate students, lecturers, and professors.

No Australian University provides an entirely free education. Total income from fees in the three largest Universities (in 1911):—Sydney, £20,206; Melbourne, £31,242; Adelaide, £9,381. The annual revenue from fees diminishes with increasing liberality in Government grants. The statutory endowment varies from £5,000 (Tasmania) to £22,000 (Melbourne). But the statutory endowment is supplemented by large additional annual

grants for special purposes. Last year (1912) the total amount of State aid received by Sydney University was £44,000, by Melbourne University nearly £47,000, or without special building grants, £37,500. New South Wales is the only State which makes statutory provision for the future increase of State aid to the University. By the *University (Amendment) Act* 1912, the statutory endowment of the University was doubled, and it was further provided that when the population returns of the State involve an increase in the number of exhibitions granted for free University education (one exhibition for every 500 persons between the ages of seventeen and twenty) the endowment "shall be increased at the rate of £1 for every fifteen persons of such increase." When the new scheme of State University exhibitions is in operation, there may be 800 students in attendance at Sydney University who pay no fees. These State exhibitions are not like other University exhibitions, tenable only in the faculties of arts and pure science. They may be held in any professional school, in a proportion to be determined each year by the Senate of the University. The Government of New South Wales has thus given effect to what has for long been an educational ideal in Great Britain and Australia—the ideal of a system which shall form a progressive and continuous whole, from the primary, through the secondary schools, to the technical colleges and the University. The Minister of Education, in introducing the Bill, said "We want to make the University the final stage in the educational scheme as laid down by the Government; to exclude nobody, but to admit everybody who has brains and application. If there has been a ladder of education it has been a ladder beset with difficulties. We want to make a road. It cannot be a royal road, but we hope to make it easier to the aggregate child-intelligence of the State." In the other Australian States, there is likewise a rapidly growing acknowledgment of the claims of the Universities for greater public support, and, while a completely free University is still indefinitely distant, considerable progress has been made towards the attainment of the ideal, without in any way lowering the standards of University admission or instruction.

At Sydney and Melbourne, there are affiliated residential colleges within the University grounds (Sydney 4, Melbourne 3), but only a small proportion of the students reside in the colleges. These colleges are not under University control, but they provide tutors, who supplement the instruction given at the University, mainly in the faculty of arts. In Melbourne, where attendance at lectures in arts and law is not compulsory, though non-attendance is exceptional, the colleges play a more important part than in Sydney, where attendance at University lectures is compulsory in all faculties. The colleges, while admitting students without respect to religious creed, are closely connected with religious denominations—Church of England, Roman Catholic, Presbyterian, and Methodist. The Women's College in Sydney is non-sectarian. In Brisbane three residential colleges (Church of England, Presbyterian, and Methodist) have been established in connexion with the new University of that State. At the other Australian Universities there are at present no residential colleges.

The University of Queensland, although it maintains the principle of a teaching University, makes certain concessions to external students. Brisbane does not occupy the same dominant position as the capitals of the

other States, and there are a number of excellent provincial institutions in Queensland capable of supplying instruction in the more general subjects. External students are aided by a well-organized correspondence study department.

Courses of evening lectures are provided at some of the Universities for students who are unable to attend during the day, and the new Universities of Queensland and Western Australia propose to make special arrangements for such students. Melbourne University provides evening lectures in a selected number of first and second year arts subjects, also in agriculture, mining, and architecture. (Number of students in attendance in 1912, 81.) Sydney University provides almost a full arts course for evening students, and nearly all the courses in the school of economics are given in the evening. (Attendance in 1912, 286.)

The University extension movement has not been a success in Australia, except to a limited extent in New South Wales. Very few University extension courses have recently been given in Victoria or South Australia. The Sydney University Extension Board, during period 1908–12, provided courses of lectures at 56 country centres. During 1912, 47 University extension courses (3–6 lectures) were given in New South Wales (average attendance, 122).

Since the oldest University in Australia has been in existence for little more than 60 years, and the latest is only a year old, the influence of University education on the national life has been naturally a thing of slow growth. The first task, after providing for a broad liberal education, was to institute courses of professional education. Law and medicine were the first professional faculties established. The Australian Universities are now well represented in all the higher Courts of Justice in the Commonwealth. The first three Judges of the High Court of the Commonwealth were all graduates of Sydney University. Melbourne had a medical school in active operation long before the Sydney Medical School was established in 1883. Sydney has now over 600 medical graduates; Melbourne has over 1,000. Official statistics as to the proportion of Australian qualified, to foreign qualified, medical practitioners in the Commonwealth are not available. A private analysis of the medical registers in four States shows the following result. The figures are approximate, as some of the medical registers are very imperfect:—New South Wales, foreign qualified practitioners, 654; Australian, 569. Victoria, foreign, 541; Australian, 681. Queensland, foreign, 241; Australian, 150. South Australia, foreign, 146; Australian, 142. Western Australia, foreign, 182; Australian, 102. Medical schools exist only in Sydney, Melbourne, and Adelaide Universities. Australian graduates in science and engineering are now to be found in all the more important mining and industrial enterprises of Australia, and on the field in various parts of Asia, Africa, and America. The Australian Universities have also been represented in recent South Polar expeditions. Important original investigations in Australian geology, biology, anthropology, etc., have been conducted by Australian University teachers and graduates, whose work has been recognised by foreign Universities and learned societies. The more recently established professional schools are now making their influence felt in the gradual raising of the higher standards of technical education.

Only within recent years have serious efforts been made to extend the facilities offered for post-graduate instruction and research. A small annual grant is made in some cases for providing Science Research Scholarships (1912—Melbourne. £2,000; Sydney. £1,000). In a new University the teaching function dominates. The teachers, especially in the faculty of arts, are overburdened with formal lecturing and class work, and have too many subjects in charge to permit of the necessary specialization. Yet, in spite of these restrictions, the annual output of original work is highly creditable to the Australian Universities, especially in the scientific departments, where the teachers are in less bondage to the formal lecturing system.

Important changes have been made in the governments of the Universities and their relation to the other parts of the national system of education. The representative character of the senate or supreme administrative body has been broadened. and now. in nearly every case, contains government or Parliamentary representatives. The Universities and the Education Departments have been brought into closer contact. to their reciprocal advantage, without loss of University independence or freedom of teaching. Extended public and Parliamentary interest has led to a wonderful increase in the number of the various professional and scientific departments. but sufficient thought has not been given to the greatly increased expenditure which will be necessary for the effective equipment and maintenance of the new schools. The faculties of arts have made, comparatively speaking, less progress, although chairs of education and economics have in some cases been added. There are still lacking chairs of ancient history, psychology, political philosophy, and sociology. It is a matter for astonishment that no school of sociology has yet been established in any Australian University. A fairly complete department of economics exists at the University of Sydney, but no special instruction is provided in sociology. In all the Universities, the arts curriculum is now arranged so as to allow a fairly wide list of "options," the general aim being to avoid the two extremes of premature specialization and dissipation of energy over an excessive number of different subjects.

Among the Universities, Melbourne was until lately, perhaps, the most conservative, and Sydney the most advanced in the arrangement of the arts curriculum. but Melbourne University has now (1913) considerably revised its regulations and curricula for degrees in both arts and science. Adelaide provides, more than the others, for specialization during the arts course. It is probable that, with greater development, the traditional arts faculty will be replaced by a faculty of liberal studies, composed of a number of relatively independent departments. In that case. the entrance standard would require to be raised. and the present first year courses would be left to higher schools and colleges.

The Australian Universities come into contact with the other departments of national education mainly on two sides. higher school education and technical education. In the absence of any departmental organization of secondary education, the Universities of Sydney, Melbourne, and Adelaide instituted junior and senior public examinations, on similar lines to those adopted by Oxford and Cambridge. These examinations have now fulfilled their function, and will gradually disappear, to be replaced by higher school

examinations, controlled by a conjoint board, representing the Education Departments and the Universities. The matriculation examination will be retained only for the benefit of those who do not qualify for admission by means of the leaving certificate.

The general unsatisfactory condition of technical education in Australia has been already described. It is not in the least probable that the Australian technical colleges will develop into technical Universities on the German model. Future development will be on British lines, a greater extension of the higher scientific-technical work at the University, which should be the highest centre of training, and at which all the great national interests should be represented. The technical colleges will be organized so as to free the Universities from great part of the necessary elementary scientific instruction, and to supplement the University by affording material facilities for specialized technical application and research.

Complaints have been made that the Australian Universities stand outside the national life, in dignified but dangerous isolation. The charge is usually made in loose general terms, and with a childish ignorance of the evidence. Sometimes what is meant is that the University should open its doors to the incompetent. At other times, the reference is to the comparatively small number of graduates who adopt politics as a profession. The Universities conceived their first duty to be the provision of a liberal and professional education. For any extension of their work they had to depend on increased Government grants. It is not the Universities, but the State Governments, who have failed in the necessary task of providing systematic instruction at the Universities in economic, social, and political science, as part of a training for public and political life. During the present year (1913) a Workers' Educational Association has been formed in several of the Australian States, a non-party and unsectarian association, with aims similar to those of the present English association. The Australian Universities are entering into sympathetic relations with the new movement, and some of them have already taken steps to establish tutorial classes on the model of those which have been so successful in England.

Students of education will have recognised in this condensed account many parallels to English and Scottish educational policy and development. According to the census of 1911, 96·99 per cent. of the total population had been born either in Australasia or in the United Kingdom. The two largest foreign-born elements of the population were German (0·75 per cent.) and Chinese (0·47 per cent.). The Australian people is indeed more homogeneous than the parent stock, and its future development may be more easily predicted than that of the United Kingdom. Foreign institutions and modes of life rarely become acclimatized, which is a misfortune in some instances, *e.g.*, art, cookery, architecture, and the more refined kinds of social recreation. The Australian national system of education is strongly akin in many features to the French national system, but there has been no direct borrowing. French influence has come by way of England, which was greatly affected during last century by the social and political ideas and example of France.

One grave defect of a highly centralized system has already been mentioned, its failure to secure corresponding local interest and effort. The attempt to stimulate the sense of local responsibility, by means of single or

district school committees, has, up to the present, been a wretched failure. Victoria is, perhaps, the only State where rural schools in general show any appreciable improvement due to local interest or expenditure.

Another defect of a centralized system of national education is, according to some writers, that it means a machine-made teacher and a standardized child. The criticism was directed against the English board school, and so far may have been warranted. But with the new system of training teachers, in close contact with the University, and with the consequent free play of ideas, the danger of the machine-made teacher is diminished. The danger becomes serious only when the chiefs of the service are impervious to new ideas, and when the rank and file are excluded from the broadening and inspiring influence of a University education. Such conditions no longer exist in Australia, and there is little fear of their being restored. "Standardization" is a term too vague in its reference to be anything more than a question-begging epithet, like "democratic." Standardization is not necessarily an evil. It is not an evil in good manners or in the essentials of a sound liberal education. Changes in the methods of examination and inspection, and greater freedom in the detailed carrying out of the new programmes of instruction, which are very broad and intelligent in conception, have already done much to counteract the tendency to mechanical uniformity in the routine of school work.

A final danger of the centralized system of national education is said to be the opportunity which it puts at the disposal of a reactionary or tyrannical Government. With an army of instructors, drilled into a common subservience to regulations from head-quarters, a nation may in a generation or two be turned from free men into slaves or machines. This fearful prospect alarms the imagination of those who live constantly in dread of the "coming socialism." To one who has grown old in the service of the Australian people, the danger seems illusory. The leviathan of a self-organized democracy is not likely to be the fearful monster conjured up in such alarmist dreams. It is no doubt possible, even certain, that the future holds surprises for social optimists, as well as for social pessimists. But even supposing that the worst which is feared should become true, there are still grounds for the faith that the period of reaction or tyranny would be only a temporary lapse from the ideal of a free national self-development. The free spirit of a nation may be trusted to react, sooner or later, on its own institutions, which that same spirit has created. The churches, whose main reason for existence is to bear witness to the reality of a moral order, may be trusted to keep alive the conviction that nothing can permanently prevail against the spiritual forces which rule the world. And the national Universities may be trusted to do their part. Only when the Universities in older lands became class institutions did they fail to fulfil their high function, and become instruments of reaction and subservience. As the centres of free and enlightened thought on all the great human interests, the national Universities of Australia will not, it may be believed, fail to supply men of light and leading for the nation. The Universities of the past sent forth men who withstood Popes and Emperors. The Universities of the future may be trusted to provide men who will not bend the knee before King Demos, or acknowledge any other master than the spirit of freedom and truth.

CHAPTER XIII.

POLITICAL SYSTEMS OF AUSTRALIA.

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SYNOPSIS.

1. The Federal System of Government.

The *Commonwealth of Australia Constitution Act* 1900 recites the agreement of the people of New South Wales, Victoria, South Australia, Queensland, and Tasmania to unite in "one indissoluble Federal Commonwealth under the Crown" and under the Constitution thereby established, and provides that the Colonies (with Western Australia if she join in the agreement) shall accordingly be united by proclamation of the Crown upon a day appointed. The proclamation was made on 17th September, 1900, and on 1st January, 1901, the appointed day, the Federal Commonwealth came into being. Western Australia having by this time accepted the Constitution, the Commonwealth included the whole six colonies.

The foundation of the Commonwealth and the Constitution upon an Act of the Imperial Parliament checks all argument as to the legal origin of either; we are thus spared some of the speculations which political communities of this type appear to invite. It enables us also to recognise the agreement of the colonies as at any rate the *causa sine qua non;* such recognition in no way impairs the unity of the Act of Constitution or suggests dangerous rights of secession. In complete accordance with the doctrine of colonial self-government laid down for Australia in 1850, the union and its conditions (subject to some alteration of the provisions concerning appeals to the King in Council) were framed in Australia itself, and the Imperial Parliament in passing the Statute which gave them legal form acted as the supreme constituent authority in the Empire.

An extensive literature exists on the subject of the several unions of States, and no definition of a federal union could be offered which would not challenge criticism. For purposes of description, however, it may be said that a federal government exists in any political community where the powers of government are divided between two authorities—a central authority extending to the whole territory and population, and a number of particular authorities limited to particular areas and persons and things therein—each of which is equipped for its own purposes without recourse to the other, and which are so far independent of each other that neither can destroy the other or impair its powers or encroach upon its sphere.

If it is asked why the Australian colonies preferred a federal to an incorporate union, the division to the concentration of power, the most obvious answer lies in the fact that where several States, independent of each other, come together to form a new political community, there is, in the absence of any imperative force, a strong bias against complete self-surrender and absorption. The same cause influences the form which federalism is likely to assume—in its most natural shape, the constituent States will not only preserve their own identity, but will reserve the general powers of government and will commit to the new federal authority specific powers only.

This tendency will be the greater if the union is formed under the auspices of the existing Governments and of State politicians. It may be overcome if the union is achieved either by or in the presence of force, as in Germany, where the Empire was founded on the military supremacy of Prussia, whose hegemony is stamped upon the Constitution. In South Africa, the deliberate preference for an incorporate union was due to a variety of conditions, chief amongst which were that the fundamental divisions of South African politics transcended colonial boundaries altogether, and (it may be surmised) that the pathway to union was beaten out by men whose position in the country enabled them to view the conditions with detachment from local prepossessions and connexions.

That the Canadian Constitution gives the residuary power to the Dominion Parliament and only specific powers to the Provinces is no exception to the rule. In addition to the fact that in the years 1864–1867, when the "confederation" was forming, the United States was a neighbour flushed with the spirit of American unity, is the fact that the Dominion Constitution was not merely nor mainly a union of the British North American colonies; it was, so far as concerned its principal members—Ontario and Quebec—a dissolution of the incorporate union of Upper and Lower Canada and the substitution of a federal bond.

In Australia, all these exceptional conditions were absent. There was no imperative external pressure—the questions of the Pacific and of a White Australia had not then assumed the importance which later events and a wider outlook have given them. Union was a governmental convenience rather than a necessity, designed for the attainment of certain obvious and practical purposes, more apparent to men of political experience than to the multitude. In such circumstances, it was natural to build on existing foundations, to leave things unchanged except so far as change should be necessary to secure the practical ends in view. It is not necessary to lay stress upon mutual jealousies, and the impossibility of obtaining union upon other terms. To do so is to suggest that the Constitution was to its framers a *pis-aller*, an acceptance of the second best; and there is no reason for doubting their belief that the great interests which they had in view would be served by a government with powers definitely limited and pointing towards those ends better than by one which was burdened with the miscellaneous functions of a Parliament with plenary powers. An ardent national spirit and widespread national consciousness have been the growth of the twelve years since federation was accomplished: the product of a sense of common external interests and possible dangers on the one hand, and, on the other, of more clearly defined differences in political thought and aims.

The position, as it presented itself to federalists, cannot be described better than in the resolutions of the National Australasian Convention of 1891 :—

"That, in order to establish and secure an enduring foundation for the structure of a Federal Government, the principles embodied in the resolutions following be agreed to :—

"1. That the powers and privileges and territorial rights of the several existing Colonies shall remain intact except as to such surrenders as may be agreed upon as necessary and incidental to the power and authority of the National Federal Government.

"2. No new State shall be formed by separation from another State, nor shall any State be formed by the junction of two or more States or parts of States, without the consent of the Legislatures of the States concerned, as well as of the Federal Parliament.

"3. That the trade and intercourse between the federated Colonies, whether by land carriage or by coastal navigation, shall be absolutely free.

"4. That the power and authority to impose Customs duties and duties of Excise upon goods the subject of Customs duties, and to offer bounties, shall be exclusively lodged in the Federal Government and Parliament, subject to such disposal of the revenues thence derived as shall be agreed upon.

"5. That the naval and military defence of Australia shall be entrusted to federal forces, under one command.

"6. That provision shall be made in the Federal Constitution which will enable each State to make such amendments in its Constitution as may be necessary for the purposes of the federation."

These principles were emphasized in the Federal Convention of 1897–9.

A clause in the draft of 1891, making the Governor-General of the Commonwealth the channel of communication between the Imperial Government and the States, was omitted in the final scheme ; and the Canadian plan, which gives to the Dominion Government the appointment of the Lieutenant-Governors of the Provinces and a veto on provincial legislation was carefully avoided. The object of the Constitution was to mark out the sphere of the Federal Government, to ensure the completeness of the power of that Government in its sphere, and to leave the rest—the States' Constitutions, their frame of government, and their powers of government—unchanged.

2. Responsible Government.

In considering the structure of government, the States first demand attention, as being the earlier in time, and the schools of experience in which the framers of the Commonwealth Government learnt their work. In all other aspects than the federal, the experiences of the Colonies under responsible government so obviously govern the Constitution, whether for warning or for example, that it will be convenient to let one account serve for both Federal and State Governments, merely calling attention to significant points of difference.

Five of the federating Colonies acquired "responsible government" between 1855 and 1859; Western Australia did not reach her political majority until 1889. The mode in which the several Constitutions were established was not uniform, and in some cases presented singular complications and obscurities.

But ultimately, all may be founded on some Act of the Imperial Parliament conferring upon a Colonial legislature the amplest power. While the Imperial Parliament has thus been the origin, it has also been the model of the Colonial Constitutions.

The government of the Colonies is essentially self-government; the Colonial legislatures are not limited by any doctrine which would treat them as the mere instruments of the Imperial Parliament. And just as the British Constitution rests on a legal basis of Parliamentary sovereignty as distinguished from people's sovereignty, the self-government of Australia has meant Parliamentary government, unhampered by limitations which an authority merely delegated by the people would suggest. The most important manifestation of this is that self-government in a Colony has included the power of amending its Constitution, and that the constituent power has been lodged in the Colonial legislature without further reservation than is involved by the observance of forms which the legislature itself may abolish, and, in some cases, has abolished.

The assumption of "responsible government" involved several things, of which the full significance and appreciation were only disclosed by time. It meant that, in relation to the internal government of the Colony, the Imperial Parliament and Government abstained from interference in matters of policy and administration. This consideration governed the exercise of the reserved power of disallowing Colonial legislation, as well as of the ordinary powers committed to the Governor by the Crown.

It meant also the transfer of power from a Governor, with a staff of subordinate officers, answerable like himself to the British Government, to an executive which was responsible within the Colony itself. It has meant, in practice, that this responsibility has assumed a form similar to that which has grown up in the United Kingdom since the beginning of the eighteenth century. In short, "responsible government" has acquired a secondary meaning connoting "cabinet government" or "party government," so that in the Colonial legislature we find not merely the legislative authority but the power which makes and unmakes Ministries.

This is foreshadowed rather than established in the Constitution. In spite of expressions in the Constitution, which assume the existence in fact of the system, the Cabinet system rests to this day in Australia mainly, as it does in England wholly, upon conventional understanding and practices rather than upon positive law. Thus, in addition to the flexibility which belongs to a legal framework alterable by the ordinary legislature, there is the further flexibility arising from the free play of usage and convention. The once famous theory of Higinbotham (Chief Justice of Victoria), which attributed to the Constitution Acts the whole system of responsible government, now finds few supporters. The legal part of the Australian Constitution until the establishment of the Commonwealth was mainly concerned with the Legislatures, their organization and arrangements.

3. Parliaments and their Constitution.

All the States' Constitutions provide for two Chambers. The Assembly, or Lower House, is democratic in basis; and in its control of Ministers, its financial preponderance, its limited term, and its liability to dissolution, recalls the House of Commons.

In all the "Lower Houses" members have long received an "allowance" or "reimbursement of expenses," which is in substance a salary. The Senate of the Commonwealth, and the Legislative Councils of South Australia, Western Australia, and Tasmania are also paid. In addition, members receive a pass over the Government railways, and, in some cases, allowance for travelling expenses, while there may be further allowances for special service, as on the Standing Committee on Railways in New South Wales and Victoria, or on Royal Commissions of Inquiry. It may be mentioned that a procedure similar to that by which payment of members of the House of Commons was introduced in 1911—the inclusion of the necessary amount in the Appropriation Bill—brought about a Constitutional crisis and "deadlock" in Victoria in 1877, though payment of members had been provided for by temporary Acts since 1871.

Manhood suffrage for the Lower House has been universal for many years; women's suffrage upon an equal qualification was introduced into South Australia in 1894, and was adopted by Western Australia (1899), New South Wales (1903), Tasmania (1903), Queensland (1905), and Victoria (1909), and by the Commonwealth in 1902. Every adult is entitled to vote in the district in which he resides. Plural voting is permitted in no State and is forbidden for the Commonwealth Parliament, but in Victoria and Queensland property-holders have an option of exercising their vote where the property is situated, or where they reside. The result in Victoria is that while Melbourne is at a general election a safe Labour seat, at a by-election it is pretty certain to be won by an anti-Labour candidate.

A new country presents few of those features which in older governments suggest competing methods of distributing representation amongst the constituencies; and thus the electoral units are found by dividing the electorate into districts, with an approximately equal number of electors. One important modification of this plan is adopted: some advantage is given in the distribution to rural over metropolitan electors. This is founded on various grounds, but exists mainly to establish a balance of interests, and especially to reduce the disproportionate weight of an urban vote concentrated in the capitals. It is recognised in the Commonwealth as well as in the States.

In the States of Queensland and New South Wales provision has been made for the redistribution of seats, due to changes in population, without need for recourse to special legislation. In the other States there is no such provision, and time produces similar anomalies to those found in the United Kingdom. In the Commonwealth Parliament the matter, of course, touches the relative weight of the States in the Parliament, and is, therefore, provided for by the Constitution, supplemented by legislation. It is the business of the Chief Electoral Officer every fifth year to take into consideration the representation of the several States in relation to the statistics of population, and to determine whether any State has lost, and any other State

gained, a member, for the system contemplates adjustment by transfer and not by an increase of the total number of members. This determination is operative *per se;* and it then becomes the duty of the Government to order commissioners to redistribute the seats in the States concerned, in order to give effect to it. The commissioners' reports are laid before both Houses of Parliament, and, if approved—they cannot be amended—pass into operation. The question suggests itself—what would be the position, if, after the Electoral Officer had made his determination, either House of Parliament should refuse its assent to any consequential adjustment? The reports of commissioners are by no means accepted as of course, and are the occasion of fierce party battles in the House. The machinery of the law may also be called into operation by the shifting of population within a State.

The single-member constituency is the rule in Australia for the Lower House; but Tasmania has for years used an adaptation of Hare's system of proportional representation, involving the multi-member electoral division. The States have made various experiments in schemes for determining the majority of votes where there are several candidates. New South Wales adopted the second ballot in 1910 as a means of coping with the "split vote" where party discipline was not sufficiently strong to deal with the matter; the scheme was naturally opposed by the party which could rely on its own organization to prevent rivalry from its own ranks. Queensland, in 1892, Western Australia, in 1907, and Victoria, in 1911, have adopted various forms of "contingent" or "preferential" voting. Of the general effect of the schemes, it cannot be said that they have failed in their aim, though, with the increased sharpness of party conflict and the growing strength of party discipline, they appear to have come on the stage just as the conditions which demanded them were passing away. On the other hand, the party system itself peculiarly demands provision for the representation of minorities. Possibly, the single-member constituency may, in general, secure this in a haphazard way, though the expectations on which the English system of 1885 was based have been singularly falsified in practice. The Commonwealth Senate, with its multi-member constituency, shows what is possible with a block vote as directed by a powerful organization. No provision, however, has been made, except by Tasmania, for the representation of minorities. The disadvantage of all such schemes is that among a people fairly evenly divided in their politics, nice and accurate adjustment of their representation makes Parliamentary government difficult and may involve the whole institution in discredit. This consideration, of course, does not apply with equal force to Second Chambers, and it is possibly in connexion with an elective Upper House that proportional representation promises the best results.

The ballot has been so long in use in the United Kingdom (though its experimental character is recalled by the fact that it still depends on an annual Act) that people forget that it used to be described as the "Australian ballot"; Australian experience was an important factor in encouraging its adoption in England. In recent years, Australia has been making some further experiments in the mode of recording votes. Partly, though not solely, out of consideration for women electors, various provisions have been

made for recording votes otherwise than by attendance at the polling booth in the elector's division. The most important of these has been "voting by post," introduced in Victoria in 1900, and adopted by Queensland, Western Australia, and the Commonwealth. It has been fiercely assailed by the Labour Party as permitting violations of the secrecy of the ballot, and obviously, if admitted as a general alternative, it would afford a means whereby any person or political party able to bring pressure upon the elector could readily make that pressure effective. Actually, voting by post is limited to cases of illness, distance from polling booth, and absence. But in Queensland it was asserted that the system was abused, and after a constitutional crisis in 1907, the law was amended in 1908 so as to permit electors to record an "absent vote" at any booth. The same course was followed in the Commonwealth, where the Labour Party abolished the postal vote in 1911, and substituted "absent voting" at any polling booth in Australia. The objection to this system is that it facilitates impersonation by diminishing the risks of detection. Needless to say, the views held on the subject are affected by the interests deemed to be involved. The postal vote facilitates the recording of women's and farmers' votes, which are thought to favour the Liberals. The absent vote provides for the shearers, seamen, and other shifting classes who vote "Labour," while it does nothing for the farmer who is distant from a polling booth, or the woman who is suffering the infirmities of sex. It is by no means certain that the calculations of interest on the subject by either party are sound.

In the organization and procedure of the Chambers the English model is closely followed, and *May's Parliamentary Practice* is as familiar as in the House of Commons. The closure in various forms is now acclimatised in Australia. There is usually a time limit for speeches on motions for adjournment, and in the Commonwealth Parliament a rule was made in 1912 limiting speeches in the House of Representatives to 65, or in certain cases 95 minutes. In the Commonwealth Parliament and in some of the States Parliaments, the consideration of Bills introduced in one session may, under certain restrictions, be resumed in the next session of the same Parliament at the stage they had reached at the prorogation.

In the Commonwealth Parliament the Speaker's robes and the mace were discarded during the last Labour *régime*, but were restored in the Parliament of 1913. A more serious breach with English traditions has recently been made in the practice which frankly treats the Presidency, the Speakership, and the Chairmanship of Committees as party appointments to be determined anew in each Parliament.

4. The Two Chambers of the Legislature.

The second Chamber in Australia is foreshadowed in the composition of the Legislative Council established in New South Wales in 1842, which consisted as to one-third of nominated and as to two-thirds of elected members. Much discussion on the subject took place in the following years, when Australian constitutions were in the making. Succeeding Secretaries of State, the Board of Trade, and members of the House of Commons in England; the Governors, Legislatures, press, and public meetings in the Colonies took an active part. To one, the tradition—English and

Colonial—seemed a sufficient reason in favour of the two Chambers; to another. the adoption of the English model appeared to invite a comparison which will lead to embarrassing claims by the Colonial Assembly. Others again desired a Second Chamber as a guarantee for the presence in political life of persons of independence and character, a Chamber which should at once be a brake upon "naked democracy" and a model of tone and disinterestedness in public life. While such a Chamber might be relied on to stand between the Government and the onslaughts of a democratic Chamber, it must not be merely the creature of Government, or it would lack respect and influence. Therefore a life tenure for nominees was to be preferred to a limited term.

It is curious to note that in the discussions preceding responsible government, the common assumption on all sides is that a Council will be a supporter of Government; and the critics of Government address themselves to considering whether it is better to have the Government phalanx in the Assembly or in a separate Chamber. The Constitution contained in the Imperial Act of 1850 left the settlement of the question to the Colonies themselves, provisionally continuing the form of Legislature set up in 1842.

In the result, New South Wales and Queensland adopted nominee Councils, South Australia, Tasmania, Victoria, and (when her time came) Western Australia, elective Councils. In the elective Councils, the franchise varies in details, but its character may be judged by the fact that the proportion of Council to Assembly electors is from 30 to 40 per cent.

In contrast with the Assemblies, which are dissolved by lapse of time or prorogative act, the Councils have a continuous existence. Moreover, whether the Council be a nominee body, whose members have a life tenure, or an elective body, its *personnel* changes very slowly. Successive reductions in some of the States of the term for which a Councillor is elected give an uniform tenure for six years, one third or one half of the members retiring by rotation every second or third year. But save in rare instances a member once elected retains his seat for life or until resignation. Constituencies are large; contests are expensive; public interest centres in the Assembly; the Council offers no temptation to ambition. Members of Council are generally older than Members of the Assembly, who are themselves middle aged; well-to-do, sometimes wealthy, men, whose property, business, or profession, and not politics, has the first claim on their time and attention. They have claimed to stand outside the party system; there has not been the same sharp division of their ranks as in the Assembly into Ministerial and Opposition. The party division has probably been more marked in the nominee Councils than in the elective, and it becomes more pronounced with the infusion of Labour members which the nominee system permits. But any Government may meet a check at the hands of a Legislative Council, however constituted. Not claiming to make and unmake Ministries, it does not recognise the obligation or the discipline of a party. When a Ministry is being formed, the Premier will include one or two members of the Council chosen less for their political views than for their persuasive influence in a small body which has learned to trust itself to the guidance of a few of its members. If these members have the necessary capacity and

time available, they may be the means whereby the Council fulfils its revisory function with much public benefit.

Designed as conservative bodies the Councils have certainly fulfilled the retarding function of a Second Chamber. Nearly every measure which is claimed as democratic and progressive has had to pass the ordeal of several rejections. The several extensions of the franchise, including women's suffrage: payment of members: land taxation: the whole range of "experimental legislation" from schemes for land settlement and compulsory purchase to wages boards and arbitration courts: the extension of government enterprise into the sphere of trading, have their long account of Bills rejected by the Councils. Even so well-tried a measure as Workmen's Compensation is in some cases still held back. The resistance of the Councils to drastic schemes for breaking up the large pastoral holdings and to land taxation, and the brake they apply to "socialistic legislation," have driven many, if not into the ranks, at any rate to the support of the Labour Party, and have been the main cause of the zeal of that Party for enlarging the powers of the Commonwealth Government, in whose constitution a forward policy has to encounter no such obstacle.

Yet when all is said, Australia is able to pride herself on the multitude and variety of her legislative experiments, and with some justice she has been regarded as the world's political laboratory. When the Government and the Assembly have been very much in earnest—which is not always the case—and have been supported by a strong public opinion, the Councils have usually given way.*

The nominee and elective Councils have of course presented distinctive problems in the long course of struggle between them and the Ministries. In the case of the nominee Councils the first question was the respective functions of Governor and Ministry in respect to nominations. In the view of the Governor (supported at first by the Colonial Office), it was essential to the usefulness and independence of the Council that its *personnel* should not be altered so as merely to reflect the shifting conditions of parties in the Assembly; that though there was no legal limitation to the number of members of the Council, a conventional limitation should be accepted, and that appointments should in general be made only as vacancies arose by death or resignation. Ministers, on the other hand, contended that in this matter, as in others, self-government required that the Governor should accept the advice of Ministers or find successors. On this subject, the earlier plan has been modified to the extent at any rate of abandoning the notion of a conventional limitation of numbers; and in 1892 Lord Ripon accepted the principle of Ministerial responsibility, subject to the qualification that the Governor should act upon his own opinion if he had ground for believing that the Ministry was not supported in its action by the Assembly and the country. This appears to have been the principle acted on by the Governor

* A critic, however, might often have applied to the situation created the comment of a shrewd parliamentarian on the relations of the Cabinet and the Lords in England: "An Upper Chamber which will accept from a Ministry that it detests no measure that has not behind it an irresistible mass of excited public opinion has sooner or later the fate of those Ministers in its hands. For on the one hand the friction generated by the process of forcing a Bill through a reluctant House of Lords annoys and scandalizes a nation, which soon grows tired of having a revolution once a twelve month; and, on the other hand, the inability of a Cabinet to conduct through both Houses that continuous flow of legislation which the changing necessities of a country like ours demand, alienates those amongst its most ardent supporters who take little account of its difficulties and see only that it is unable to turn its Bills into Acts." (Trevelyan, *Life and Letters of Macaulay*, 2. 56.)

of Queensland in 1907 when, on the rejection of certain Government measures by the Council, the Premier asked for assurances, to be publicly notified, that persistence in the opposition would be followed by the appointment of a sufficient number of Councillors to enable the Government to carry out its policy. The Governor refused, the Ministry resigned, and a new Ministry accepted office on the understanding that an immediate appeal would be made to the country. A general election returned the old Ministry to office, and the Council accepted the Bills. The consciousness that the remedy of further appointments was available has been in all recent times a factor in inducing the Councils to accept legislation, as for instance the Land Tax in New South Wales in 1894; and in 1899 additional members were, in fact, appointed to carry the Federation Bill.

In Queensland, the crisis of 1907 resulted in the legislative adoption of the *referendum* as an alternative method for settling disputes between the Chambers. In New South Wales, the anti-Labour Government in power in 1910—which had had its own difficulties with the Council—introduced a scheme for the prevention of deadlocks, at the same time providing for a legal limitation of the number of members of the Council. Some definite determination of the numerical relations of Council and Assembly is, of course, essential to all schemes which look to an ultimate adjustment of the differences of the Chambers by a joint sitting.

In the colonies which adopted elective Councils, the differences between the Chambers have been more frequent and acute. From the first, the Councils, as being elected, have been able to claim that they are responsible to their constituents, and particularly to urge with some force claims to a participation in financial policy greater than that of the House of Lords or of a nominee Chamber. In South Australia and in Victoria the differences between the Houses in these matters have been sharp; and in Victoria, on three occasions—in 1865, 1867, and 1878—the rejection of the Appropriation Bill has brought the Government to a standstill.

The memory of these conflicts remains, and was very apparent during the debates on the Federal Constitution in 1897-1899. Two remedies have suggested themselves. As early as 1874, the Government of Victoria appears to have intended to propose the substitution of a nominee for the elected Council; and a Bill for the purpose was actually introduced in 1880, but did not obtain the absolute majority required. The remedy generally favoured and ultimately (1903) adopted leaves the principle of election unaffected, but makes provision for "deadlock." The joint sitting, the substitution of a suspensory for an absolute veto with or without a *referendum*, the dissolution of one or both the Houses—these schemes in various combinations have been discussed at various times. South Australia led the way with a provision whereby if the Assembly twice passed a Bill, with an intervening general election, the Governor might on the second rejection by the Council dissolve both Houses. This provision is in force to-day, with an alternative whereby the Governor may afforce the Council by issuing writs for the election of additional members. In 1901 and 1908 attempts were made by the Government to substitute a joint sitting after a measure had been twice rejected by the Council; and in 1910 and 1911 the Labour Government introduced and passed through the Assembly Bills whereby any scheme twice passed

by the Assembly and rejected by the Council might, if again passed by the Assembly after a general election, be passed over the head of the Council.

In 1911 the Council rejected the Appropriation Bill. The Government, following the course taken by the Victorian Government in 1878, appealed to the Imperial Government to give effect to the proposals of the Bill of 1911, but was met with a refusal. It then dissolved the Assembly with a view to a later double dissolution, but the country was against it. The political history of South Australia during the last twenty years is one of constant conflict between the Houses—of unsuccessful attempts to reduce the franchise for the Council and to establish more practicable means for making the will of the Assembly and its electors prevail. Women's suffrage, though applicable to both Houses, has widened the distance between Council and Assembly by lowering the proportion of Council electors to electors for the Assembly, and this fact is an important element in the situation.

In Victoria, disputes between the Council and the Assembly were at last dealt with by the Constitution of 1903 under a plan suggested by the Commonwealth Constitution. On the rejection of a Bill by the Council, the Governor may by proclamation dissolve the Assembly declaring the cause of disagreement between the Houses. If the new Assembly again passes the Bill and the Council rejects it, both Council and Assembly may be dissolved. The scheme proposed that the new Council and Assembly should then hold a joint sitting: but this had to be abandoned owing to the Council's opposition. The result therefore is that if each House is supported by its electors, there is no machinery for ending the dispute. It should be noticed that even the plan established is qualified and surrounded by precautions and safeguards. A dissolution of the Assembly within six months of its expiry by efflux of time does not count, and no part of the scheme applies to provisions altering the Constitution of Council or Assembly. On no occasion has the machinery of the Act of 1903 been put in operation, though the Council has been active in criticism and in rejection of Government measures.

When we pass from the Legislative Councils of the States to the Senate in the Parliament of the Commonwealth we are in a wholly different atmosphere. The framers of the Constitution were spared the fundamental problem of determining the basis of a Second Chamber, for they had a principle ready to hand—the representation of the States as such demanded at once by federation and by the practical exigencies of the situation. Equal representation in a Senate was after a struggle conceded to the six States. Each State is a single constituency, and the term of service for a Senator is six years, so arranged that half the Senators from each State retire every three years. The large constituency and the continuity of the Senate stand for the attempt to reproduce in the Senate something of the character of the ideal Second Chamber. But if violence was done to the democratic principle of equal citizenship by giving the same number of senators to all States regardless of population, an attempt was made to atone for it, as well as to avoid the repetition in Commonwealth Government of the experiences of the colonies, by making the qualification for Senators and electors the same as for members and electors of the House of Representatives, and by providing for payment of Senators on the same scale as members of the House.

The Senate has equal powers with the House in ordinary legislation. But as to finance, a detailed and complicated scheme aimed at securing first the preponderance of the House of Representatives in relation to the "ordinary annual service of government" and, as a consequence, the primary responsibility of the Government to that House; and, secondly, the protection of the Senate against every form of tacking, whether by lumping various projects of taxation in the same measure, or by including schemes of expenditure outside the "ordinary annual service of government" in the Appropriation Bill, or by joining Bills of legislative policy with finance measures. (See the *Commonwealth of Australia Constitution Act* 1900, sections 53–56.) For the Senate was, like existing Upper Houses, not to have power to amend finance measures, though it was compensated by a power to make requests.

The possibility of conflict was foreseen, and section 57 provides for a double dissolution followed by a joint sitting in case the Senate twice rejects or fails to pass a Bill sent to it by the House of Representatives.

The experience of twelve years shows the Senate in constitution, in action, and in reputation very different from the design. The Constitution aimed at a combination of cabinet government with federal government, and there were prophets who foretold that the alliance was unnatural, and that one of the two must destroy the other. In the Commonwealth, cabinet government with its tradition of the supremacy of the Lower House, appears to have prevailed. To the Senate have been assigned two* members of the Cabinet, of whom only one would be a Minister with a portfolio, and the protests of the Senate against such scurvy treatment have been wilfully ignored. The absence of Ministers handicaps the Senate both in its legislative and in its critical capacity, for Ministers can only take part in the proceedings of their own Chamber. Very little legislation is initiated in the Senate, which during the earlier months of a session has little to do, while towards the close of a session it is rushed with work, and before appeals to facilitate public business even the revisory function of a Second Chamber has to give way. It has little of the corporate feeling of the Legislative Councils; it is more definitely organized as "Ministerial" and "Opposition"; and it would be idle to look to the Government supporters to champion Senate claims against the House.

As a federal House of States, the Senate has long ceased to raise any expectation of activity as a guardian of State powers and functions; and the conference of State Premiers has developed in part at least as the result of its failure in this respect. As a Second Chamber, it has been docile beyond expectation. In place of the cautious attitude of the Councils towards the legislation of a "progressive" Ministry, the Senate has shown a fiery zeal for experiment, and the leisure which it enjoys as an Upper House has been employed in the debating of motions for the nationalization of "monopolies," the further regulation of trusts and combines, and the enlargement generally of Commonwealth powers. These debates would have had more value if the Senate could have been taken seriously as an effective part of the constitutional machinery. But so long as it deferred to tradition by leaving to the House the active work of government while, unlike the Councils, it

* In the Liberal Ministry of 1913 there were three Senators.

accepted readily the legislation sent to it, it was esteemed in the community as little more than a debating society.

This quiescence, however, depends on a political situation which is liable to change, and which in fact was changed by the general election of 1913. The elections of 1910 and 1913 returned Parliaments sharply divided into two parties. In the Parliament of 1910, the Labour Party had a large majority in both Houses; in the Parliament of 1913 there were in the Senate 29 Labour members and 7 Liberals, while in the House of Representatives the Liberals had a majority of one. The Labour Ministry retired on the declaration of the polls, and the Liberal Ministry, having to part with one of its supporters as Speaker, faced the equal ranks of its opponents in the House. This is the situation at the time of writing (August, 1913). As the Ministerial proposals include the repeal of several measures of their predecessors it is evident that the Senate is likely to play an active part in the present Parliament. The result will probably be to make reform of the Senate an important plank in the Liberal programme.

The Senate, indeed, is vulnerable from a democratic point of view in the unequal value assigned to individual citizenship by the equal representation of States. It has become vulnerable also by the mode of election for Senators. The three Senators returned for each State are elected upon a block vote which requires the elector to vote for three candidates and prohibits him from giving more than one vote to any candidate. The enormous constituency, which prevents a candidate from becoming personally known to the electors, makes the party and its organization predominant in elections. As parties obtain more control over the candidature and as electors vote more strictly on party lines, a small majority in any State is likely to secure the whole number of seats for that State. With a certain amount of luck, the same Party may in the same way secure the three seats in each of the States. This is what happened at the election of 1910, when eighteen Labour Senators were returned. In 1913, three States returned three Labour Senators, two returned three Liberals, and one returned two Labour Senators and one Liberal. At each election, the difference between the votes cast for the two parties was trifling. Some of the strongest objections to proportional representation—that it is apt to leave parties too nicely balanced or to favour the formation of small groups, and that it deprives elections of the driving power which comes from a large turnover of seats—have little or no application to a Second Chamber, which is, indeed, usually designed with the object of preventing the body from being too radically changed at any one time. The alteration of the electoral system of the Senate by some provision for the representation of minorities is a reform in which all parties should be able to agree.

5. The Cabinet.

So far as concerns the Cabinet in the Australian States, there is little that needs description. In general, the substance, and perhaps even more the forms of British practice are observed. The Ministry may not dominate the Assembly as much as the English Cabinet to-day dominates the House of Commons; it has been said to be less sensitive to defeats which are not a direct challenge to its authority. Collective responsibility is often

a strain where party lines are not clear and Ministerial supporters are drawn from various groups, or where the regular Opposition is not sufficiently strong to threaten the Ministry. Reconstructions are called for by dissatisfied supporters, and sometimes take place. They would be more frequent if it were possible to break the fall of an unpopular Minister in an agreeable way. The secrecy of Cabinet proceedings is guarded well enough in matters of the first importance. But in Australia, the number of departmental matters dealt with in Cabinet is very large, and this has probably been responsible for a recent practice whereby frequently a *communique* is made to the press, summarizing the results of the Cabinet council. The number of Ministers is small, and while in England the more important Departments of State have at least two Ministers in Parliament, the Australian practice frequently assigns two and even three Departments to one Minister. As it is impossible for a Department to be represented directly in both Houses, the Cabinet includes two or three "honorary Ministers," "Ministers without a portfolio" who may share the conduct of Government business in the Legislative Council, and sometimes assist the Ministers in their Departments: and Victoria has adopted a feature of parliamentary government in Europe which permits Ministers in charge of a Bill to take part in the proceedings of the other House. As all Ministers are in the Cabinet, there is no training for Ministerial responsibility such as is afforded by the Under-Secretaryships in England. Often a preliminary term is served as an "honorary Minister," and on a casual vacancy in a Department, the succession is commonly looked for by an honorary Minister. On the other hand, as there are no sinecure offices like the Privy Seal or the Chancellorship of the Duchy of Lancaster, honorary office is sometimes accepted by men who are unable or unwilling to undertake heavy departmental work. The same reasons that in England warn the Prime Minister not to accept an onerous Department exist in Australia. In the Commonwealth Government, Mr. Deakin became Prime Minister "without a portfolio," and during the succeeding Ministry the office of Prime Minister was definitely constituted as a distinct "Department of State."* Another result of the system by which there are no Ministers outside the Cabinet, is that the Attorney-General has always been in the Cabinet, a fact which gives the office a political rather than a professional character. It has in fact been held by gentlemen who were not members of the legal profession at all.

"His Majesty's Opposition" has more formal recognition than in England, for the leader of the Opposition usually has an official secretary at the public expense, and in Queensland he receives a salary.

6. Party Government.

The Australian colonies in adopting the British system of cabinet government as their mode of self-government, took a course which provided for their immediate need of submitting the executive to colonial control. The system was one which in outline they understood, though even in England, outside official and parliamentary circles, there were probably few people in 1855 who could claim to know it intimately. The

* In the Cook Ministry the Prime Minister became Minister for Home Affairs, but arranged that one of the honorary ministers should practically administer the Department.

conventions of the system were accepted so far as they were understood. A Government held office by the support of the Assembly; that support might be withdrawn without any breach of propriety by the House and without injustice or hardship to Ministers. Opposition was a constitutional function and not unpatriotic or factious conduct, if accompanied by an acceptance of the responsibility to assume office in certain well-defined contingencies.

But such a system presents obvious temptations and dangers. In the absence of real differences of policy, it is apt to become a game in which men exercise their natural combativeness and rivalry, and in which Ministerial office is the trophy awarded to the victors, a trophy which they hold on condition of defending it against all challengers. A lower level is reached if the contest is dominated by material rewards, when government is perverted by self-interest, loses all moral influence, and ceases to be representative in anything but name. If changes of Ministry are based on real differences of policy, still over frequent change destroys continuity and makes government ineffective. In England, these evils have been encountered by the existence of parties, and the reduction of the contest in the main to a struggle between two parties. The small number of persons in Parliament who can look for any personal advantage from a change of Ministry; the fact that those who may aspire to office have commonly an assured social position and some fortune so that the emoluments of office though pleasant are not of vital concern, tend to check the influence of personal interests, and to force political contests along lines of real difference in matters of public policy. Moreover, in England, party government grew out of parties, called into existence in the first instance by great public issues, but ultimately having an independent existence, so that they lived not merely in the concert of their members for certain definite political ends, but in the memory of past conflicts, and of great leaders, in the possession of a name and of traditional principles and maxims of political conduct. These formed a continuous bond of association and gave the party a moral personality which could command attachment and loyalty. The leaders of the party, guiding its counsels and directing its policy, have been the most prominent men in Parliament, so that party allegiance has generally been identified with loyalty to an individual parliamentary leader or group of leading men.

Not all these conditions were reproduced in the colonies which entered on the English system in the "fifties." Australia indeed shared in the remarkable change of tone which during the preceding seventy years had gradually banished the grosser forms of corruption from public life. The legitimate pecuniary rewards of Australian politics have always been inconsiderable and a public opinion not usually very observant or interested in political affairs, has always been very sensitive at the suggestion of illegitimate gains. Even the ordinary emoluments of office probably played a smaller part in the struggle than might be supposed: office was at least as much the token of victory in the game as the material reward striven for. Certainly in the hurly-burly of the early years of responsible government, the number of men who might naturally be affected by the lure of an official salary was smaller than it was after an era of comparative stability set in.

The custom which in England draws men to Parliament as the complement to or witness of success in professional or business life, was brought to Australia by the colonists, though it has now almost passed away. But the elements from which the House of Commons still drew its character in the middle of the nineteenth century, and which furnished the traditions of political life and the basis of political contests, were incapable of transmission to those who were so far away from the influences of the "governing class." "Whig" and "Tory" made nothing of the appeal to the Australian legislator that they made in a House of Commons where men had not yet ceased to talk of "Mr. Fox" and "Mr. Pitt." "Conservative" and "Liberal" temperaments there were in political as in other affairs, finding vigorous expression in the newspaper press and readily recognisable in the general attitude of Councils and Assemblies respectively. But, in fact, the great political questions which divided parties in England—and even in England party lines from the repeal of the Corn Laws to the death of Palmerston were ill-defined—were hardly issues at all (as the extension and protection of political rights, the relations of Church and State), or they had not emerged in the social conditions of the country (as the humanitarian movement embodied in the Factories Acts, or the protection of industries by Tariffs). These conditions were unfavorable to the formation of firm and continuous associations for government. The nearest approach to party in the English sense was the habit whereby associations formed for some special purpose served as a bond of union for general political action: and the most permanent and characteristic of political groups came to be determined by fiscal sympathies, even when the fiscal question was not the question of the hour. But the bond was a slight one, and it rarely included as a practical test of party loyalty the acceptance of the leadership of some one who could speak and act for all. Outside Parliament, party, in the English sense, with its accompanying organization, did not exist: the member counted mainly upon his personal influence and popularity in his constituency and his record or services to that constituency; he was without fear of any caucus drawing inspiration from head-quarters. Such conditions permit a freedom of political action which many to-day may envy. But they are not favorable to the smooth working of the cabinet system; they tend in particular to make an assembly a congeries of local interests. It is not surprising that in Australia the combinations of politicians for public ends were transient and not permanent, and that public life developed personal rivalries and jealousies marked with intense bitterness of feeling. Ministry followed Ministry with rapid succession, and between 1856 and 1894 New South Wales had 28 Ministries; Victoria, 27; South Australia, 42.

This condition of things would hardly have been tolerable but for three facts. In the first place, the limited range of colonial politics demands less of "strong" government than is called for in a sovereign State. In the second place, there was sufficient of general political agreement in the country to insure a steady movement of democratic progress—there were few marked periods of reaction. In the third place, "government" in a colony is in a very large degree administration, which is not substantially interfered with by political change.

In a country whose sparse population and generous distances make effective local government impossible, where extensive developmental work has to be undertaken, and where social conditions and opinion combine to demand a wide sphere of governmental activity, Parliament readily becomes the meeting ground of material interests, where the rural constituencies are contending with each other for the expenditure of public money on roads and bridges, where the town and country are jealously eyeing each other, and where justice to one interest is often possible only by placating a number of others. In the condition of the country, these interests had to find representation, and it is useless to quarrel with the fact. The evil lay, of course, in their tendency to dominate the situation, to lower the tone of politics, and to form a public opinion which found a serious basis in some material interest. The last tendency was not diminished by the fact that the greater political issues were the disposition of the public lands and the tariff.

7. The Labour Party.

It was the existence in Australia of the great capitals which eventually organized politics on definite lines. At once the seat of government and the centre of all business, the point at which substantially her whole trade entered and left a colony, each capital brought together a vast working-class population with every facility for organization for political action as soon as the inducement to organize became sufficiently strong. During the nineties the Labour Party was chiefly conspicuous as a driving force in politics, supporting such Ministries as would promise industrial legislation or a land tax. In other conditions, the appearance of such a "third party" in Parliament would have been a disturbing factor. In Australia, however, the advent of the Labour Party appears to have had from the first a steadying influence in the Legislature.

The Party was soon sufficiently strong in numbers generally to hold the balance of power, and its strength was beyond its numbers by the "pledge" which bound its members on all vital occasions to cast a solid vote. But it was essentially a party striving to achieve results by parliamentary action, not one concerned merely to embarrass and hinder government, while it was not strong enough to be under any temptation to make a bid for office, and its system forbade coalescence with other parties to form a Ministry. So long as it could work fairly well with an existing Ministry, it was content to criticise it unsparingly, but not to withhold its support. It was under these conditions that government was carried on in most of the colonies during the years immediately preceding Federation, and in the Commonwealth during the Ministry of Sir Edmund Barton and the first Ministry of Mr. Deakin.

As the Labour Party grew in strength till it ceased to be a "third party" and became the regular Opposition, and later itself came into office, the other sections in Parliament were learning something by its example in the way of cohesion, discipline, and organization; while the growing prominence of the policy of nationalization, the rigour of the "pledge," and the ascendancy of the trades unions, served to mark out clearer lines of division by allying the business interests of the towns with the farming interest in the country in defence of what could honestly be held as great and permanent principles of political conduct and social well-being.

In regard to any political party, as President Lowell has well pointed out, the first question is whether it works within or without the institutions of the country. Tried by this test, we find that the Labour Party is organized for parliamentary action and accepts the main conventions of Cabinet Government. But it has certain features of its own which distinguish it from the familiar working of the older parties in England.

The *caucus* of members of the Parliamentary Party—with other parties occasional, and usually a signal of distress—is a weekly event during the Parliamentary Session; and from it sometimes spring standing committees to watch over departments of public affairs assigned to them. The chairman of the *caucus* becomes the leader of the party in the House, and if he is called on to form a Ministry it is the *caucus* which determines by ballot the *personnel* of the Government, though the distribution of offices is left to the leader. In the caucus also take place the serious debates of the Party in regard to its parliamentary action, and here we come to the root of the matter—the pledge. Every candidate for nomination as a Labour candidate must, in addition to his acceptance of the platform, undertake not to nominate as a candidate unless selected by the organization (which involves submission of his claims to the same authority before every election), and pledge himself to vote in Parliament in all matters affecting the platform as a majority of the Parliamentary Party in caucus determines This itself covers a wide range of political action; and practically (and in some cases expressly) it extends to all matters of sufficient importance to affect the life of a Ministry. Obviously, a system which commits to a majority the control of the whole party vote is one from which much of the moderating and persuasive virtue imputed by political writers to "party" has gone out. The pledge and the caucus have lost the party many supporters, and are assailed with force by opponents. They are defended on the ground of their efficacy, and if experience justifies the claim, opponents will probably end by adopting or adapting the system. Already the Liberal Party is making a more general use of the caucus, and it is almost accepted that a conciliation conference should precede hostile action in Parliament by discontented supporters of a Liberal Ministry. Any considerable extension of the system must profoundly affect the character of Parliamentary Government as heretofore understood.

In place of a Chamber deliberating in public on the affairs of the country, we may see a body split into two party delegations, holding their deliberations apart and in secret, and meeting in the Chamber merely to record a vote determined on in caucus. In England, the feature of the day is the domination of the House of Commons by the Cabinet. But in Australia, the prevalence of the caucus would threaten the Cabinet as much as the House. Where the caucus elects the Ministry, the regular sessions of the caucus must, it would seem, tend to supersede the deliberations of the Cabinet, at any rate while Parliament is sitting; to bring Ministerial differences to the arbitrament of the party meeting instead of to the Cabinet or the Premier; and to substitute for the collective responsibility of the Cabinet to Parliament the individual responsibility of Ministers to the caucus.

Amongst the methods which have suggested themselves as a means of escape from or mitigation of Cabinet domination in England has been a more

extended use of the committee system, by analogy to the methods of local government. It is possible that in Australia the movement is one from government by the Cabinet to direct government by the parliamentary majority, acting perhaps through committees presided over by a Minister.

In England the predominance of the Cabinet in the party is fortified by the disposition of honours, and by the not inconsiderable patronage which still remains to Ministers. In Australia the Cabinet has none of these aids. But there is one other factor—the organization of the party in the country. In England the party organization outside Parliament has been the fighting instrument and the intelligence department of the parliamentary leaders, whose officers—the party whips—have controlled the party funds. The policy of the party has been formulated by these leaders, who have made their own appeal to Parliament and the country. In Australia the Labour organization has at once a more formal and a more commanding part. The fighting platform is the immediate party programme which every parliamentary candidate must accept, and which, if elected, he is pledged to carry out as far as circumstances will permit. This platform is determined on by periodical conferences of delegates from branches of the State league. The conference also chooses a standing executive, in which members of Parliament are not especially prominent, and which, indeed, may easily become their censors. The question of responsibility to the conference was in fact raised in 1913 in New South Wales in a fashion which produced a condition of acute tension, and threatened a serious disruption of the party, for the conference claimed in the most definite way to review the political action of the Parliamentary members of the Party, including the Ministry, and to punish what it should adjudge to be their shortcomings and want of zeal. It remains to be seen whether this claim—which was not generally acknowledged by members, and was repudiated by Ministers—was merely a sporadic outburst, or constitutes a definite development of the system of the Party. The success which the Labour Party has won is so much attributed to the completeness of its organization, that opponents are moved to imitate it, and though among them no organization has attained a strength which enables it to dominate policy, the position, taken as a whole, suggests that the political centre of gravity is moving away from Parliament. It seems possible that Australia may have to follow American and European examples of *legal* recognition of parties, at any rate so as to regulate the process of selecting candidates.

It is not surprising therefore, that there should be much speculation as to the form responsible government may assume in the near future. There are on the one hand those whose ideal is that of Cabinet and Parliamentary government, with what they deem its essentials—general party loyalty to parliamentary leaders, with such freedom of individual action as will maintain the deliberative character of Parliament and the responsibility of the Cabinet to the representatives of the people, subject to the present power of dissolution in the hands of the Government as a means of appeal from the representative to the constituency. From this point of view, pledge, caucus, and conference, and the precise and intricate features of the organization, are mechanical substitutes for the essential qualities of reason and judgment, and have the grave defect of dissipating responsibility. On the other

hand, the election of Ministers in Parliament, fixity of tenure for the life of the Parliament, or until the passing of a direct vote of censure, abandonment of collective responsibility, and abolition of the prerogative of dissolution are suggested, and in various combinations find many advocates. Such means, it is urged, will secure at once stability in administration and freedom in parliamentary action. More recently, journalistic enterprise has imported from America or Switzerland the "initiative" and the "referendum," and Labour leaders have given them a hesitating approval. According to this plan, the way of salvation lies in recourse to the direct action of the people in the work of legislation. Parliament is frankly treated as a mere instrument for recording the people's will; it is not a deliberative assembly of the wise. The organization of parties in Parliament is an ineffectual attempt at compromise between two conflicting views of government, and the next step in constitutional development is to provide machinery whereby an educated democracy may take its part in direct government.

8. Administrative Problems.

One of the most constant problems of modern government is the relation of the political part to the administrative part of the system. The Cabinet meets some of the difficulties; the responsibility of Ministers to the Legislature permits that they may be intrusted with a considerable discretion, and removes from the legislature the temptation of meddling with the detailed work of government. The subordination of other officers of Government to the Ministers enables the Legislature to treat Ministers as solely responsible. Ministers on their part with some show of justice might claim that they cannot be responsible for those whom they cannot control; that, therefore, a discretionary power of appointment and dismissal must be in their hands if they are to answer for efficiency in administration. It is unnecessary here to recur to the mischief of political appointments and dismissals in the public service; but it may be pointed out that the restrictions involved in guarding against the evil are some charge upon the services of the State.

In England it has hitherto been found possible to regulate the Civil Service without recourse to law, whether as to appointments, promotions, or tenure of officials. In Australia, the Public Services are governed by elaborate statutory provisions defining the conditions of admission, the classification of officers, remuneration, promotion, and discipline. The administration of this body of laws is organized under a Public Service Commissioner or Commissioners, whose important functions are recognised by statutory provisions designed to secure him against Ministerial pressure. Through his hands pass appointments and promotions, and one of his principal functions is to guard against the inflation of the service. In promotions, he has to weigh seniority and efficiency, and here lies his main responsibility. Any perfunctory performance of his duty will load the higher ranks of the service with indifferent officers; a painstaking and conscientious selection of junior officers is apt to evoke the cry of favoritism. Democratic principle rejects any such division of the service as exists in England, where a special class of man is introduced after a severe and competitive educational test to fill the higher offices. In Australia, the entrance examination for all

candidates is not a very convincing test of ability or education; the successive ranks are filled by promotion from below according to rules which limit the area of selection. For professional or technical positions there is greater freedom of choice, and the tendency appears to be to give to the chief of such officers in a Department the functions of a permanent head. The establishment of the Commonwealth Government and the need for organizing Departments before the passing of a Public Service Act gave the opportunity for securing some of the best ability available whether within or without the services of the States; and the expansion of public activities calling for the creation of new branches or Departments from time to time gives similar opportunities to both Commonwealth and State. The Commonwealth Public Service Act is emphatic in its insistence upon efficiency and its relegation of seniority to a subordinate position.

There has been no indication in Australia of any tendency to make use of the Public Service as the election agency for Ministers, as appears to be common in some countries. Any such tendency, if it had existed, would probably have been checked effectually by the elimination of direct political control under the Public Service Acts. But the relation of public servants to politics has engaged serious attention in Australia, as in all other communities where the solidarity of interest in a large body stimulates common action for the protection or promotion of that interest, and where from the nature of the case organization is peculiarly easy. The Parliament of Victoria was, in 1903, so far impressed with the perversion of the public interest which might arise from the pressure of public officers upon members of Parliament and Ministers that the whole Public Service, including the railway service, was removed from the territorial divisions for electoral purposes, and was formed into special constituencies. This, however, was repealed in 1906. In the Commonwealth and in New South Wales, the public servants have the benefit of the Arbitration Law, and, as has been seen, the Commonwealth has made more than one attempt to bring the State railway servants under Commonwealth control. Such measures are based on the view that, as Government can hardly concede to its servants the right to strike, it is bound to provide them with the means of laying their claims before an indifferent tribunal, and that a legitimate mode of pressing these claims serves to remove the subject from the political and parliamentary arena, where it would be determined less according to its merits than according to the amount of effective pressure which could be applied at the moment.

Generally, the usual restrictions are imposed upon the political activities of public officers. But in the case of the Commonwealth, the Labour Government in 1909 removed these restrictions and left the Commonwealth service free to engage in the ordinary political action of citizens, subject to a prohibition against commenting upon the administration of any Commonwealth Department and disclosing or making use of official information.

Within the Departments, Ministers in Australia probably concern themselves far more with detail than do Ministers in England. Whether this in all cases conduces to a more real control over the policy of the Department may be doubted.

The desire to eliminate "political influence" from administration has not been confined to the matter of the Civil Service. There are many matters

undertaken by Government which call for special expert ability, others which demand an unbiassed judgment in dealing with conflicting interests. This has been recognised in varying degrees as imposing limitations upon the sphere of the political part of Government, so as to promote efficiency in management (as in the case of State railways) or to avoid the intrusion of the miscellaneous factors which necessarily enter into any political judgment. The management of the railways is vested in Commissioners with large powers of independent action, combining the functions of managers with many of the powers of a Board of Directors. The relations between the Minister and the Courts in such a system are delicate, and are occasionally strained. Parliament, which has to find the money for any railway deficit, must have control over commitments to large expenditure; the relations between the Courts and their staff may call for the interference of the Government and Parliament as a matter of national policy. But this public and occasional interference is not open to the objections attaching to Ministerial management with the constant pressure of political considerations. Railway construction may be either an incident of management or a matter of policy. After some hesitation, it has been treated as a matter of policy, the more particularly as in Australia the construction of railways must be viewed not merely as a business enterprise but as a means of developing national resources.

On the one hand, Parliament is entitled to determine the place of railway construction amongst the various claimants for public expenditure, and to determine the order in which the various railway schemes are to be undertaken. as well as to judge of the plan of the work, so far as concerns, *e.g.*, estimates of cost. On the other hand, there is no matter in which the decision of a political authority, whether Minister or Assembly, is more liable to be affected by influences outside the merits of the case. The position has been recognised by some States in the establishment of a Standing Parliamentary Committee to which all but insignificant schemes of railway construction are referred for investigation and report, and which performs functions analogous to those of the private bill committees of the Lords and Commons.

The principles applied in the case of the railways are applied in greater or less degree in other business relations between the State and the citizens, first as a means of securing efficient management, and, secondly, as a means of ousting illegitimate influences. The Savings Banks of the States and the Commonwealth Bank are illustrations. Similarly, in the administration of the intricate body of laws for the regulation of the Crown lands, it has been found advisable in some cases to constitute semi-judicial and special Boards with carefully defined statutory powers for dealing with the resumption of lands for closer settlement and the management and rating of irrigation areas. The disbursement of funds by the central Government for the construction and maintenance of roads is another matter which hovers between independent management and political action. The Inter-State Commission, established by the Labour Government in 1912, has an immense range of powers in relation to Inter-State trade and commerce, and is, after the railways, the most important case of the use of an independent body in administration. Some of the powers of the Commission arise under

the Constitution itself—a finding of the Commission is in certain cases made a condition of Commonwealth action. In other cases, the Commission is intrusted with the amplest powers of investigation, upon the results of which may be based legislative or administrative action, or judicial proceedings. In particular, the Commission is charged with a constant surveillance over the operation of the Customs Tariff, avowedly that Parliament may act upon authentic information and unprejudiced advice in reconciling the several interests which a Tariff, especially a protective Tariff, affects. The Commission is in many respects assimilated to a Court of Justice, and its members, though appointed only for a term of years, have during that term the security of a High Court Judge. It has been stated that the Liberal Government which assumed office in 1913 proposes to vest the management of the postal and telegraphic services in a body of Commissioners modelled as to status and functions upon the Railway Commissioners.

The existence of these semi-independent authorities involves in many cases great complexity of function and relation, with the possibility of sharp conflict between them and Ministers. Ultimately, it involves very difficult constitutional questions as to the responsibility of Ministers for the exercise of statutory powers vested in particular bodies or officers. Usually there are left in the Ministry powers which in the last resort will make the political view prevail; but the country has the safeguard that such interference is an extraordinary and not an ordinary exercise of power, that it almost necessarily takes place in circumstances which insure publicity, and that it must therefore be based on reasons on which the Ministry can rely as a justification of its action.

Local government in Australia is entirely the creation of Statute, but so far as it goes it carries the tradition of local government in England—that is, it is viewed as local self-government and not as the instrument of the central Government. In fact, there is in Australia less of the utilization of the machinery of local government for national purposes than there is in Great Britain. Police (together with the maintenance of prisons and the cost of justice) and education are services organized and controlled by central departments, and the expenditure is provided for by Parliament. The same is true of asylums. There is no poor law, but a considerable charity vote is usually granted by Parliament, and the subsidizing of benevolent institutions and the relief of unemployment are regarded as State rather than municipal matters. Old-age pensions were provided by the State Parliaments, and their administration was undertaken by the central departments; they are now, with invalid pensions and the maternity bonus, administered by the Commonwealth Government through officers responsible to it. As the railways are in the hands of the State Governments, those Governments are brought into closer relation than elsewhere with the internal communications of the country; roads and bridges are important feeders of the railways. Moreover, these communications are of course essential to development, and are often most urgently called for where there is least ability to bear a local charge; and historically there is a connexion between land revenue and local works. Large amounts of money have been expended directly by the central Government both out of loans and revenue; and there are roads and other works, distinguished as "national" from those controlled

by local authorities. In general, roads are now made and maintained by the shires or municipalities, with the aid of a Government grant. It is questioned whether this system altogether insures recognition by the municipalities of the national purposes for which the subsidy is paid, and recent legislation in Victoria is aimed at bringing main roads under a much more direct control through the establishment of a non-political board.

A large part of Australia is now included in local government areas; but it is obvious that the effectiveness of local government must vary with the widely different conditions of settlement in the several States. In the capitals and other urban areas, government is organized upon familiar lines, and undertakes the obvious services required by large town communities. Both in Sydney and Melbourne, the existence of a large number of municipalities within the metropolitan district involves the creation of some authorities which control services not admitting of separation, of which sewerage and water supply are the most important.

9. The Courts and the Constitution.

The general principle of the division of powers between Commonwealth and State, as already stated, is that the Commonwealth received authority over certain matters specifically enumerated, while the Constitution reserved to the States the residuary power: the federal plan is that of the United States Constitution.

Federal government, with its division of power between two authorities, demands some method of settling the frontiers and determining the rival claims. It rests upon the assumption of a controlling law, and therefore a sovereignty above each of the governments concerned. In such a system government is in a peculiar degree based on law: as Professor Dicey has said, "Federalism is legalism." How that controlling law manifests itself in action will depend largely upon the history and traditions of a country; it does not necessarily, as the cases of Germany and Switzerland show, find expression in the arbitrament of the ordinary courts of law. But amongst people bred under the influence of the English common law, the control of the law has meant in Australia, as in America, the submission of the Constitution, with its definitions of and limitations on authority, to the interpretation of the courts. In countries where the idea of law is more abstract, it may be possible to conceive a constitution existing in an atmosphere outside that of the courts, and yet with a legal and not merely a moral or conventional obligation. But though the British Constitution and its offspring know well constitutional rules which are not cognisable in the courts, they deny them the name of laws. That is law which is enforced in the courts; for that which is not enforced in courts, English legal philosophy does not readily find a name. Even in Germany, with a legal philosophy widely diffused through her government, the idea of law, unsupported in constitutional relations by the action of the tribunals, appears to be giving way before the tendency of the self-determining legislature to augment its powers.

A system in which the courts of law are called upon in the course of their ordinary business to consider the validity of Acts of Parliament is strange to those who live under the rule of parliamentary sovereignty, and in communities whose constitutions were modelled on the Imperial Parliament the

adjustment to a new order has been not without some difficulties and heart-burnings. The principle, indeed, was universally accepted. The rule that Imperial Acts applying to a colony are of paramount authority was familiar enough; and it was obvious that if two legislatures with authority over the same matter spoke with a discordant voice, the courts could not give effect to the will of both, and must hold that one prevails over the other. The occasions for such a conflict of Imperial legislation with colonial legislation under "responsible government" were few. In the case of a federal constitution where the powers of the central Legislature were in general not exclusive, but concurred with powers of the States Legislatures, such conflicts must be of constant occurrence; and the Constitution expressly provided that in such a case the laws of the Commonwealth should prevail. In this class of case the task of the courts has been to determine what is inconsistency, a more difficult task than appears on the surface. But in order that a Commonwealth Statute shall prevail or, indeed, operate at all, it must be a "law," *i.e.*, not merely passed by Parliament, but within the powers committed to Parliament by the Constitution. Inasmuch as the Constitution itself is an Act of the Imperial Parliament, it is a law of paramount authority to which the courts must give effect. Where it says that such and such a power *only* shall be exercised, the courts must give effect to the limitation, and treat any excess of the grant as *ultra vires*. Thus the courts have the more delicate task of interpreting and defining the limits of the powers of the Commonwealth as often as in any litigation before them any such power is invoked. Further, the Constitution, although it is not the origin of the powers of the States Parliaments, restricts their powers in various ways, and therefore the Courts must consider whether acts of the States Legislatures or executives are within the authority left to them by the Constitution. Lastly, a written Constitution is no more than a frame of government—a certain generality and breadth of description belongs to its very nature. "A Constitution to contain an accurate detail of all the subdivisions of which its great powers will admit, and of all the means by which they may be carried into execution, would partake of the prolixity of a legal code, and could scarcely be embraced by the human mind. It would probably never be understood by the public. Its nature requires therefore that only its great outlines should be marked, its more important objects designated, and the minor ingredients which compose those objects be deduced from the nature of the objects themselves" (*per* Marshall, C.J., *McCulloch* v. *Maryland* (1819)) 4 Wheaton 316). British Statutes are characterized by a high degree of detail which invites the courts to a literal and unimaginative interpretation. A Constitution, on the other hand, is brief, allusive, the expression of some clearly discernible principles of government. These have to be worked out in application, and their consequences cannot at the outset be foreseen. Actually, the implications of a Constitution are not less important than its explicit dispositions. Constitutional construction, therefore, involves a peculiar responsibility, not merely because of the importance of the subject, but because of the special nature of the task. The courts must adjust themselves to a new stand-point. The task before them resembles less the interpretation of an Act of Parliament than the development of the common law. In the case of a federal Constitution, it

has an analogy to the process by which large departments of the law have been built up to contain "the unexpressed intention of the parties" in contract.

It is obvious that such functions as these have a vast political significance, and a system which casts them on the courts raises several grave questions. Are judges with their training well-fitted for the determination of these matters? One advantage a man of large professional experience possesses: he is accustomed to a detachment from mere personal views and sympathies in his professional judgment and conduct. But something more is needful; in the words of Marshall, "the judge must mingle with the lawyer's rigour the statesman's breadth of view." In the region of implied powers and implied restraints the legal landmarks become faint; in the interpretation of some vague indefinite power, political battle cries are like siren's songs. When great political issues hang on a judicial decision, the whole political interest of the community is ranged on the one side and the other, and by tradition the defeated litigant is not in a generous mood towards the court. Moreover, in making judicial appointments, Governments can hardly avoid giving some weight to the prospective attitude of the judge towards constitutional matters, and there is the temptation to subordinate unduly other considerations of fitness to this. The system is obviously one which puts a strain upon the Bench, the Executive, the Parliament, and public opinion.

But it is easier to point to drawbacks than to suggest a remedy if the reality of Federal Government is to be preserved. The frank acceptance of political in place of legal control involves either the paramountcy of one of the Governments concerned or of some authority external to both. In the United States, this was impossible. In Canada, the system is mixed—both Dominions and Provinces are subject to legal control through the courts, while the Provinces are subject also to the political control of the Dominion Government, which may disallow their legislation. In Australia and Canada, there is the resource of submitting some at any rate of these great questions to the political control of the Imperial Government, which has the same power of disallowance; and at the beginnings of the Australian Constitution there was in fact a moment's hesitation as to the proper mode of working out some of the problems of federalism. The Supreme Court of Victoria and the Privy Council on appeal looked askance at the American decisions as political wolves in legal sheepskin, and, rejecting all implied restraints on power in law, sought to reconcile the plenary powers of a Parliament with that mutual forbearance which federalism demands, by reference to the political supremacy of the Imperial Government and the Imperial Parliament, as a means of preventing encroachment by the one authority upon the other. Perhaps the most notable decision of the High Court is that in which it rejected this easy means of avoiding responsibilities; held that the delimitation of spheres was a legal question as to the existence of power, and not a political question as to the proper use of powers: and declared that a view which would refer questions of every-day action to the supervision of the Imperial Government was a negation of that self-government to which all Australia was accustomed, and was totally inconsistent with the notorious purpose of the Constitution to enlarge that self-government.

It was in the same case that the High Court vindicated its own position under the Constitution as against what it deemed the encroachment of the Privy Council.

The constitutional importance of the High Court of Australia arises from the fact that it is the supreme court of appeal in Australia, and that on constitutional matters, within sec. 74 of the Constitution, no appeal lies to the Privy Council except where the High Court for special reasons certifies that the question is one which ought to be determined by the King in Council. The peculiar prominence which events have given to the High Court brings us to a particular consideration of the subjects in the power of Commonwealth and State respectively.

10. Commonwealth and State Functions.

In the sphere of Federal authority, precedence must be accorded to the matters of defence and fiscal relations. Here the State services of Defence and Customs were wholly transferred to the exclusive authority of the Commonwealth Parliament. Subject to the constitutional provision of inter-state free-trade, power was given to make laws with respect to external and inter-state commerce. Two other State services, closely connected with external commerce—lighting and buoying, and quarantine—were also transferred, as was the post office, with the telegraphs and telephones. Of the 39 subjects granted to the Commonwealth Parliament, some, like "external affairs," "immigration," "naturalization and aliens," point to the established need of a single voice to speak for Australia in her external relations. Others, such as trade-marks and patents, banking and bills of exchange, go some way towards bringing "commercial law" into federal hands. Currency and coinage are always regarded as fittest for a central authority, and in Australia the power of the Commonwealth Parliament is fortified by prohibitions to the States. Weights and measures are federal for like reasons. Marriage and divorce are suggested by warnings from the United States. Alone amongst the miscellaneous powers, "invalid and old-age pensions" and an arbitration power to deal with industrial disputes passing the boundaries of any one State, were calculated to make any wide appeal to political feeling.

From the nature of the case, it is not possible to define the States' powers by enumeration. But the residuary power includes such important matters of administration as the lands, public health, mining, railways, education, police, and local government: the whole law of property and most civil rights: all trade and commerce, except foreign and inter-state commerce; and all industry and industrial relations except so far as they may be brought into the Commonwealth sphere of conciliation and arbitration by the existence of some form of dispute extending beyond the limits of any one State. The State power thus embraces those social matters which in all modern countries are arousing the deepest concern, as well as those matters of public economy which in a new country engross the greatest amount of public attention and constitute in ordinary times the politics of a dependency.

According to the view current at the time of the establishment of the Commonwealth, the task which lay before the Government at the outset was no doubt a heavy one. The organization of the transferred Departments

carried with it the need for replacing the varying laws of administration of the States by an uniform law, work of an essentially departmental kind in which Parliament would concern itself but little, and the public not at all. Defence, on the other hand, called for constructive statesmanship, but in 1900 gave little promise of prolonged or keen political interest. Then there was trade and commerce, as to which the Constitution imposed on the Parliament the task of framing an uniform tariff for Australia within two years, and declared that on the accomplishment of that task, inter-state free trade should be established. The fiscal question was thus the burning question, which in the first instance defined the lines of parliamentary parties, ranged old opponents against each other in familiar contest, brought out old conflicts of interest, and, from the divergent policies of New South Wales and Victoria, gave to the struggle something of an inter-state character. But even in regard to the tariff, there was a general desire to effect a settlement, and to relieve trade from the hindrance of a fluctuating policy. That matter settled, everything pointed to calm in the federal sphere, and there was room for reasonable doubt whether federal politics when the first work was done and the glamour of the inauguration departed, would be sufficiently stirring to attract the more robust type of politician, or to command a live public interest.

The actual history of the Commonwealth during its twelve years of life has been very different from the anticipation. The sessions of Parliament have been as long as those of the States; its proceedings have been contentious enough to produce the closure in its various forms; Ministries have followed each other in rapid succession—the Ministry which took office in June, 1913, is the tenth Government of the Commonwealth; elections have stirred the depths of political feeling and have called out the most strenuous efforts of party organization, with the result of raising the percentage of electors voting from 46.86 in 1901 to 73.43 in 1913; and the issues which have led to this public interest are exactly those which were regarded as outside federal politics. In several cases, the successful passage of an Act through Parliament has been only a stage in the conflict, which has been taken up in the courts, and eventually been passed on to the electors through proposals for the alteration of the Constitution so as to invest the Parliament with additional powers.

11. The Development of the Federal Constitution.

The first important constitutional principle laid down by the High Court was that if either Commonwealth or State attempted to give to its legislative or executive authority an operation which would fetter or interfere with the free exercise of the legislative or executive power of the other, the attempt unless clearly authorized by the Constitution was invalid. This doctrine, first laid down in favour of the salaries of Commonwealth officers against the taxation of the States, was applied to protect the States against the application of the Commonwealth Arbitration Act to disputes between the States Governments and their servants employed on the State railways. The second great principle was that, the Constitution having divided powers of Government between Commonwealth and States, the powers of the Commonwealth must be interpreted

consistently with the maintenance of the division, and therefore if a particular grant of power to the Commonwealth would according to one construction extend in substance to nullify that division and to give to the Commonwealth a general paramount authority, it must be rejected in favour of a more restricted application, consistent with the general scheme. This principle was first explicitly enunciated in connexion with what was known as the "new protection"—the policy of guaranteeing to the employés in protected industries the advantageous conditions which protection made possible. The difficulty was for the Commonwealth to accomplish this under a Constitution which left the regulation of industry to the States. By an ingenious use of the power of taxation, the customs duties were in certain cases balanced by an excise, remissible on proof of compliance with specified labour conditions. In the High Court this Act was challenged by a taxpayer, and a majority of the Court held it was *ultra vires:* in substance the Act was not one of taxation at all, it was a regulation of industry; and if the power of taxation sanctioned what had here been done the same device would enable the Commonwealth to regulate anything whatsoever, and so make the federal scheme illusory. Developing the same doctrine, the Court in subsequent cases emphasized the fact that in the region of commerce the Constitution which granted to the Commonwealth the subject of foreign and inter-state commerce, impliedly forbade it to regulate the domestic commerce of the States. The application of these doctrines was fatal to the attempt to establish the Union Label under the cover of a Trade Marks Act; to regulate the contracts of corporations under the Australian Industries Act; to establish a common rule affecting all employers in a particular industry under the Arbitration Act. It also limited the operation of the Arbitration Act in various respects, and in particular established that the Commonwealth Court of Arbitration in its awards was subject and not paramount to State laws. Finally, it limited the scope of the Commonwealth's power of inquiry by Royal Commissions to matters within the present power of the Commonwealth Parliament, and prevented the inquiries extending to matters within the exclusive authority of the States. Most of these matters had been the subject of keen parliamentary contests, which included a severe questioning of their legality. In the High Court itself, after the number of justices had been raised from three to five, there appeared a sharp division of opinion on the Bench as to fundamental principles on interpretation, and the two new justices commonly dissented from the respect paid by the majority to the reserved powers of the States.

The differences on the Bench illustrate the peculiar difficulty of the Australian situation. The Constitution has two sources—one American and one British. The federal element in the Constitution is that which is drawn from America; and the essentials of federalism were developed in the Supreme Court of the United States in conditions which precluded any exaggerated regard for the acts of Legislatures as such. The principle of people's sovereignty imported that all Legislatures held their powers by delegation and upon a trust. The Constitutions, Federal and State, were full of express restraints upon legislative competence in the interest of individual right, and, apart from such provisions, the doctrine of natural rights affected (and continues to affect) legal as well as political thought. In Australia,

most of these conditions were absent, and though the American model has furnished the federal relation in her Constitution, her Legislatures have the traditional attributes of British parliamentary institutions so far as these are possible in a non-sovereign community. Here, then, are two principles co-existing in the same Constitution, and each admittedly demanding some concession from the other. The question is—how much? Which is the preponderating principle—federalism or parliamentary sovereignty? The majority of the High Court has considered that federalism is the governing principle, and has sought its guide chiefly in the decisions of the United States, while recognising that in many matters there are differences which prevent the analogy from being perfect. The minority on the other hand has rested more on British traditions, and has relied on the principles laid down by the Privy Council in cases concerning immediately Governments either unitary in form or, like the Dominion of Canada, based on a different federation from that of Australia.

This has been the character of the legal contest. The political conflict has necessarily been waged in a less refined atmosphere.

On the policy of the "new protection" indeed there was little difference of opinion. Free-traders and protectionists alike were in agreement that where the law secured a market for the manufacturer by high duties, the law should not leave the employés to a competitive wage. The question was as to the mode in which the aim should be attained. Already there were in all but one of the States authorities for determining fair and reasonable wages, who in considering what wages an industry could bear would take into account the extent of protection which the employer enjoyed against foreign competition. But here another industrial problem arose from the establishment of inter-state free trade. A State authority could fix wages only within the State, and employers there were exposed to unrestricted competition from other States in which the labour conditions might be less onerous. The fear was excited that either the least favorable conditions for labour might be the standard for regulation generally, or industry might flow from the States with high wages to those with low wages. Unsuccessful efforts to meet the situation through a voluntary surrender of limited but sufficient powers by the States to the Commonwealth are the contribution of Liberal policy towards the solution of the problem. Labour finds in it a proof of the unity of Australian industrial conditions and bases on it a demand for unlimited federal control.

Another important factor in the situation has been the Commonwealth Arbitration Court. Designed by the framers of the Constitution for dealing with the rare case of industrial crises of national magnitude, the Court has come to be sought by the trades unions in preference to State machinery, and has become the most active of the industrial authorities in the Commonwealth. The definition of its powers and functions had been the most contentious of the tasks of the High Court. Unable to limit the terms of the Constitution to the class of case originally contemplated, the High Court has yet to give effect to the fact that the Constitution does impose some limits on the jurisdiction of the Commonwealth Arbitration Court. In the result, distinctions become very fine; differences of opinion emerge in the High Court; and the discontents of those who find barriers impeding their access to the

Arbitration Court are joined to a feeling of grievance and irritation at what is deemed the artificial treatment of great issues

12. Constitution Amendment.

The most potent factor in the political development of the Commonwealth has been the democratic nature of the Constitution, so that politicians aiming at great social and economic changes have seen before them an open way unbarred by the Legislative Councils in the States. The Labour Party has come to concentrate its main efforts upon federal politics, to use or compel the use of federal powers for purposes which make the Commonwealth Parliament and Commonwealth elections the scene of the modern social and industrial conflict. The decisions of the High Court having marked out the limits of attainment within the Constitution, the amendment of the Constitution has become the immediate objective of Labour politics and the "preservation of the Constitution" a rallying cry of their opponents.

The Labour Party, on assuming office in 1910, set themselves at once to free the Constitution from the limitations settled by the High Court decisions, and passed through Parliament a measure for altering the Constitution so as to bring under federal control all commerce and industry, including the regulation of commercial trusts, and the whole subject of labour and employment. A separate measure proposed to enable the Commonwealth to nationalize any business declared by Parliament to be a monopoly. The proposals were submitted to the electors by *referendum* in 1911. and were decisively rejected. In 1913 the proposals were again laid before the electors at the time of the general election, and were again rejected, though by slender majorities only The use of a general election for a *referendum* is tempting for many reasons, but it may detract from its value as an expression of public opinion on the measures submitted. Practically the short Australian experience appears to show that where measures for the alteration of the Constitution are promoted by a Government which is asking generally for a renewal of the confidence of the people, the electors will not separate the proposals from the Government, and their "yes" in the *referendum* goes along with their votes for Government candidates for the Senate and the House as their "no" goes with votes for the Opposition. In 1913, the *referenda* dominated all other matters as a subject of political discussion, while the personal issues of the election applied a stimulus which brought electors to the poll.

It has been said that the most important part of any Constitution is the provision for its alteration. Constitutions have been conceived as voluntary grants by the ruler, as compacts between rulers and people, as agreements of the people, and as direct expressions of a national will. A nation's concept of sovereignty is usually to be found in the provision for the alteration of its Constitution. In the Australian Constitution, the principles of parliamentary government, of democracy, and of federalism which run through the whole instrument are at work in the amending clause. Parliament has the sole initiative, and in this case must act by absolute majority. The possibility of disagreement between the Houses is provided for, and the provision differs significantly from that applicable to ordinary legislation.

The ordinary dead-lock machinery is available only in the case of bills passed by the House and rejected by the Senate, evidently contemplating conditions familiar in Cabinet Government. In regard to proposals to alter the Constitution, however, bills emanating from the Senate—the House of the States—as well as those originating in the House, have the advantage of the dead-lock machinery. Moreover, that machinery in the case of Constitution alterations is far more simple than that applicable to ordinary legislation, for it dispenses altogether with the double dissolution. It is enough that a Bill passed twice in one House has been twice rejected by the other ; in such a case it may be at once submitted to the electors for their approval. The reason for the difference in the schemes is that ordinary legislation is essentially a function of Parliament, and the reference to the people is made only as a last resort after the failure of all other methods of reconcilement. In the case of alterations of the Constitution, the people are not mere arbiters between the Houses ; they are themselves participators in the Act. Federalism has invoked the "political sovereign"—the electors—to assume a part in the "legal sovereignty." It was the people of the Australian colonies who adopted the Constitution ; without their approval no alteration in it can be made.

The alteration of a federal constitution is a revision of a compact between the constituent States. It is, therefore. reasonable to expect some recognition of this in the machinery for approving such alterations. This, in Australia, is effected as in Switzerland in conjunction with the submission to the people. An alteration of the Constitution requires a national and a federal majority—a majority of the whole number of electors of the Commonwealth who have recorded their votes, and a majority of States, the latter ascertained by the votes cast by the electors in the several States for or against the proposal. The Parliamentary representation and the territorial integrity of the States are protected by the further provision requiring the assent of a State's electors to any alteration therein.

The direct participation of the electorate in the act of amending the Constitution is no doubt a dethronement of Parliament. But the principle which governs the mode of alteration is in truth derived from parliamentary government. There is no attempt to see into the distant future, to provide by superior wisdom for generations which might not know so well how to govern themselves. The framers of the Constitution were themselves accustomed to the flexibility of constitutional arrangements ; they were themselves the product of a dynamic age and society, well aware that rigidity was not the same thing as stability. They knew, too, that while the people of Australia might accept a *régime* of law, that law must be consistent with their sense of self-government : it must no more be the dead hand of their own past than the decree of an external authority.

In America, the artificial majorities required by the Constitution and the inequality of population in the several States, combine to make large amendments in the Constitution impossible and create a problem which suggests desperate solutions. In the absence of amendment, the courts control the situation in a way which recalls the constitutional struggles of the seventeenth century in England, as even more do some of the remedies suggested. The judges are invited to make a more political and less legal interpretation ;

even to treat the Constitution as something greater or something less than a legal text—an enunciation of principles capable of indefinite modification in the face of changed social and economic conditions, and of changing political ideas concerning the relations of government to the citizen. Grave and responsible writers discuss, in ominous conjunction with these suggestions. plans for hindering the courts from pronouncing judgment against the validity of statutes, or for securing decisions favorable to their validity—special modes of constituting the bench; judicial appointments in relation to the power of overruling prior decisions; election of judges; a less secure tenure; removal by the Legislature or recall by popular vote, and replacement by "progressive" minds.

The Australian Constitution, by the ease with which it can be amended. leaves the courts no such final control. They are under no necessity to resort to bold or ingenious constructions to meet the political conditions of the country. If their decision is adverse to an Act of Parliament, it need be no more than a suspensory veto, which, if not in accord with the national will, can be readily set aside by an alteration of the Constitution conferring upon Parliament the powers desired. As already stated, the appeals which have been made to the country to alter the Constitution as interpreted by the High Court, have not met with success.

13. Imperial Relations.

The principle of responsible government was the division of functions between two authorities, each of which was answerable for its own sphere. The Colonial Government was solely answerable to its citizens for the internal affairs of the colony. Whatever touched the external relations of the colony—with the mother country, with other colonies, or with foreign States—was Imperial, which meant that it was in the hands of the British Government. Yet it was evident that in spite of the limitation of the colonial functions, some internal affairs might in certain contingencies assume an Imperial character; there must, therefore, be a reserve authority in the British Government of a controlling or supervisory kind. Attempts to state the division with legal precision were discouraged, and the scheme was consequently left free to develop through the course of political events. Time has done its work. The growth of the Colonies in population, wealth, and importance has been accompanied with a continually expanding sphere of self-government. One after another matters once deemed "Imperial" have been relegated to the Colonies, whose altered status has been recognised by distinguishing them as "Dominions." The alteration of their Constitutions is a right which in the Australian Colonies was recognised as early as 1850, and is conceded to every representative Legislature by the Colonial Laws Validity Act of 1865. By successive steps the self-governing Colonies have come to control their commercial relations with other parts of the world, whether within or without the Empire. The currency, marriage and divorce laws, the exercise of the pardoning power, the conditions of naturalization, admission and expulsion from the territory, the care of native races, have all passed into self-government. In the sphere of commerce, the Dominions are treated as distinct units, standing outside commercial treaties unless they assent to them, denouncing

them when they think fit, and in substance negotiating with foreign powers. In matters of shipping, they exercise direct control over the coastal trade and over vessels registered in the colony, and the British Government has practically abandoned control for such representations as it might make to a foreign state. The Dominions maintain their own defence forces, and control them even on the high seas. In the case of political treaties, the Empire is necessarily treated as a single unit; but it is recognised that no treaty particularly affecting the interests of a Dominion shall be concluded without consultation, and the Arbitration Treaties of 1908 and 1911 and the Pecuniary Claims Treaty of 1911 with the United States went so far as to provide for the separate assent of any Dominion affected by any question to be referred to arbitration.

In practice, then, the Dominion of the twentieth century by no means confines itself to "internal affairs." Each has its own distinctive problems in relation to the world without it, and is busy fashioning a policy to solve them. The organization of defence has been stimulated by a consideration of the special risks to which the situation and the policy of the Dominion exposed her. The old conception of "responsible government" is inadequate and seeks a new terminology and a new interpretation. Dependency on the mother country is superseded by the "voluntary co-operation" or "partnership" of the sisters; the "colonies" have become "the nations"; the Dominion's Ministers periodically assemble as "colleagues" of the British Ministers in an Imperial Conference, and are there admitted to the most secret matters of State. Where does all this tend? According to one view, the movement is towards a system of voluntary alliances, and true statesmanship lies in removing all obstructions to nationhood. It must be recognised that every "nation" has the right to make what arrangements it deems necessary for the welfare of its inhabitants and the government of its territory, even though they are detrimental to those of other nations within or without the Empire. These include arrangements of trade, the determination of the persons who shall be received as settlers, and the terms on which they shall be received. Each of the nations must assume the responsibility for its own defence, and must maintain and control its own forces. One by one the ties which bind the nations to a British Cabinet and Parliament will fall away, until the sole legal bond will be the common and equal subjection of all to the Crown. The new relation would be neither supremacy nor federation, but an equal alliance which would leave intact the sovereign right of each ally to act upon her own responsibility in foreign affairs in the last resort.

These views were enunciated by Mr. Jebb in his *Colonial Nationalism*, published in 1905. As an interpretation they made a deep impression on Australian thought, and did much to stimulate the national self-consciousness they predicated. As a forecast, however, they were accepted with some scepticism and not welcomed or acknowledged as an ideal. Yet in proportion as the "national" activities enter into the self-government of a Dominion, as its interests and policy come into contact with those of other countries, the question of responsibility forces itself into consideration. If the determination of policy and responsibility for action be with the Dominion Mr. Jebb's conclusions as to disintegration seem inevitable, whatever one

may think of the prospect of alliance. If, on the other hand, the British Government is to remain responsible, that Government must have the final determination, and with the increased activity of the Dominion Government in what used to be the Imperial sphere, the occasions for an active participation by Great Britain in the policy of the Dominions must increase. It requires no great amount of prescience to see that such a system would not work—it would be as little consistent with the traditions of Great Britain as with those of the Dominions. There is a third possibility. We may develop some organ, neither the British Government nor the Dominion Government, but composed of both, for deliberating, determining, and acting in the name of all, combining responsibility with power. As yet the periodical "Conference" with its permanent secretariat, and subsidiary conferences, is all that is firmly established. The Committee of Imperial Defence, used in conjunction with the Conference of 1911 and the conversations with the Canadian Ministers in 1912, is apparently offered tentatively as a means for more continuous consultation, but has evoked criticism as being essentially an adjunct of the British Government. It is probably true, as Lord Milner has observed, that any great step forward will demand some formal and conscious act of constitution-making. That is possible only if backed by a public opinion throughout the Empire sufficient to carry constructive statesmanship over the many obstacles which bar the path. Such an opinion does not yet exist But Australians are now at any rate conscious that there is an Imperial problem to be solved, and in their maturer political growth are less disposed than in their youth to a sensitive repugnance to all discussion of the matter as disloyal to the ideal of self-government.

CHAPTER XIV.

MISCELLANEOUS NOTES ON AUSTRALIA, ITS PEOPLE AND THEIR ACTIVITIES.

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SYNOPSIS.

1. The People of Australia.

(a) Race, Physique, and Health.

Australia is a country slightly larger than the United States of America, and nearly the same size as Europe, including Russia in Europe, the area, population, and density of population of the countries mentioned being as follows :—

Particulars	Europe	United States	Australia.
Area in square miles.. ..	3,860,368	2,973,890	2,974,581
Population	452,153,642	91,972,266	4,668,707
Density (persons per sq. mile)	117·13	30·93	1·57

The control of so large a territory by a mere handful of people naturally offers difficulties of a unique character, one of which deserves special mention, viz., that arising from the adoption of what is known as the "White Australia" policy, by which it is hoped to avoid difficulties that have arisen in some other parts of the world, where heterogeneous, or apparently heterogeneous, populations are associated in civic life.

Australia embraces 1,825,261 square miles south of the Tropic of Capricorn, and 1,149,320 square miles within the tropics, and although the highlands of the north will enable a limited but considerable number to live in what is really a non-tropical region within that tropic, the problem of peopling the north is that of establishing, in tropical regions, a white race. Experiments are being made at the present time to develop the northern portions of Australia, and valuable scientific investigations in tropical medicine, which may be helpful in this effort, are being made at the Institute of Tropical Medicine in Townsville. There is little doubt that these will throw some light upon the subject, and assist materially in bringing the problem to a satisfactory solution, if that be possible.

In regard to the range of climate of the principal towns, it may be mentioned that meteorological researches shew that the mean annual temperature at Darwin is 82·7° Fahr., while at Ballarat it is only 53·2° Fahr., while the mean annual rainfall ranges from 61·7 inches at Darwin to 9·3 at Kalgoorlie.

The Australian people, with regard to racial constitution, are virtually British, as the following figures from the last census shew, and it may be added that the descendants of other European races disclose but small differentiation from their fellow citizens of British origin. The percentages of the principal races represented are as follows :—

Australian born, 82·90 per cent. ; natives of United Kingdom, 13·37 ; of New Zealand, 0·72 ; of Germany, 0·75 ; of China, 0·47 ; of Scandinavia 0·33 ; of all other places, 1·46 ; that is to say, at the date of the census, 1911, no less than 97 per cent. had been born either in Australasia or in the United Kingdom.

The evolution of the Australian people, therefore, may be regarded as that of the British people under changed climatic, social, and economic conditions.

With regard to the physical proportions of the Australian people, a considerable number of measurements has been made in all the States in connection with the military system of Australia, and from these measurements the following table has been deduced :—

Age.	12	13	14	15	16	17	18
Height .. ins.	55·3	56·2	59.2	61·5	63·7	65·2	66·4
Weight .. lbs.	72·2	79·6	87.2	98·5	110·9	118·9	128·2
Weight divided by height (lbs. ÷ in.)	1·31	1·39	1·48	1·60	1·74	1·83	1·93
Ponderal index ..	22·8	22·7	22·7	22·7	22·8	22·8	22·9

In the above table the ponderal index is given. This index represents the ratio of the cube root of the weight divided by the height, and multiplied by some constant. When the weight (W) is expressed in grammes, and the height (H) in centimetres, one sees that the result $W^{\frac{1}{3}}/H$ is equivalent to the ratio of the side of a cube of water the same weight as the person to his actual height, and is thus a *ratio*, large for heavily built, and small for lightly built individuals, but independent of their actual weight. The ratio usually adopted is 100 times the above, and on the average is about 29 at birth, falls to 22½ at about eleven years of age, and rises to 24 or 25 in old age. Measurements of 959 Oxford University students between the ages 18 to 23 gave about 23·25 as the average. The average Australian male of the same age has a ponderal index of about 22·9, and this number was deduced from over 120,000 youths. It is obvious that the Australian is fairly well set up.

Equally remarkable with the great variety, already referred to, of the Australian climate, is its salubrity.

In regard to the death rates in various parts of the world, New Zealand occupies the premier place with an annual death rate of only 8·9 per 1,000

(1912), and next to it comes the Australian Commonwealth. For the quinquennium 1906–10 and the two years 1911–12 the death rate per 1000 was 10·75 and 10·35 respectively. There has been a fairly steady decrease for the last thirty years, the death rate being 15·63 for the quinquennium 1881–5. This decrease of over 30 per cent. in so short a time is very remarkable. The similar rates for 1911 for other countries are:—Canada 12·6, Norway 13·2, Denmark 13·6, Sweden 13·8, Netherlands 14·5, United Kingdom 14·8, the German Empire 17·3, France 19·6, Italy 21·4, and European Russia 31·1, this last, however, being for 1905.

The table hereunder of rates per 1000 of the population for deaths from various causes reveals certain striking features to which attention may be drawn. In the period covered by the table, infantile mortality has fallen from 126 per 1000 to about 70, a little over one-half. Typhoid, which was 0·55 per 1000 in the quinquennium 1881–5, is now only 0·12, diphtheria and croup, which were 0·51 in 1886–90, are now only 0·16, and pulmonary tuberculosis has decreased from 1·31 to 0·66, say, to one-half. Cancer, on the other hand, has about doubled, having increased from 0·36 to 0·75. This diminution in the frequency of death from tuberculosis and increase in that from cancer is however general.

DEATH-RATES FROM VARIOUS CAUSES.

Period	General Death Rate per 1,000.	Infantile Mortality per 1,000	Typhoid Fever per 100,000.	Measles per 100,000.	Scarlet Fever per 100,000	Diphtheria and Croup per 100,000.	Pulmonary Tuberculosis per 100,000	Cancer per 100,000.
1881–1885	15·69	126	55	8	7	43	131	36
1886–1890	14·85	120	52	3	5	51	121	42
1891–1895	13·32	108	25	10	4	35	107	50
1896–1900	12·75	112	34	11	4	16	95	58
1901–1905	11·76	97	22	4	2	10	89	63
1906–1910	10·75	78	16	2	1	10	75	70
1911 & 1912	10·95	70	12	8	1	16	66	75

These favorable facts are reflected in the average length of life of the Australian people, as is disclosed in several tables hereafter, the whole evidence shewing that, if we except New Zealand, the position of Australia is unique with respect to its healthiness.

(b) Longevity of Australians.

During the last quarter of a century, Australia, together with almost every other country, has given indications of a decided increase in the longevity of its people. Contrary to popular opinion, it appears probable that native-born Australians of European stock will attain ages at least equal to those attained by their immigrant forbears. Such indications are furnished (*a*) by the diminishing crude death rates experienced, (*b*) by the increasing numbers of old persons recorded at successive censuses, and (*c*) still more satisfactorily by the increase in the expectation of life deduced from the mortality experience of the population for successive decades. Whilst (*a*) and (*b*) are indications which may easily be misleading, (*c*) is practically unexceptionable, taken in conjunction with the increasing proportion of Australian born in the population of Australia.

Life tables for the several States and for the Commonwealth of Australia as a whole were prepared in connection with the Australian census of 1911. These tables furnish results for each sex and for each of the three decennial periods 1881–90, 1891–1900, and 1901–10. It may be mentioned that this is the first occasion on which a comprehensive investigation of the mortality experience of the Australian States has been undertaken.

For the Commonwealth as a whole the following table furnishes the numbers surviving at successive vicennial ages out of 1000 at birth according to the six Commonwealth tables :—

OF 1,000 MALES OR 1,000 FEMALES BORN, NUMBERS SURVIVING TO DIFFERENT AGES, ACCORDING TO AUSTRALIAN MORTALITY EXPERIENCE, 1881–90, 1891–1900, 1901–10.

Age	Males			Females.		
	1881–1890	1891–1900	1901–1910	1881–1890.	1891–1900.	1901–1910
0	1,000	1,000	1,000	1,000	1,000	1,000
20 . ..	766	803	845	791	825	865
40	641	698	759	675	725	780
60	435	502	568	500	566	632
80	104	126	143	157	186	214

These figures indicate that, according to the latest Australian experience, $56\frac{3}{4}$ per cent. of all males born will reach age 60, and $63\frac{1}{4}$ per cent. of all females, while no fewer than $14\frac{1}{3}$ per cent. of all males and $21\frac{1}{3}$ per cent. of all females born will reach 80. At the present time the result is probably still more favorable. These results are an interesting evidence of the increasing numbers of survivors according to the successive experiences. For instance, while, according to the 1881–90 experience, $43\frac{1}{2}$ per cent. of all males and 50 per cent. of all females born would reach age 60, according to that for 1901–10, these proportions are, as mentioned above, increased to $56\frac{3}{4}$ per cent. for males and $63\frac{1}{4}$ per cent. for females.

A different view of this improvement in rates of mortality is given in the table hereunder, which furnishes for various ages the average annual Australian rates of mortality per 10,000 for the three decennia 1881–90, 1891–1900, and 1901–10 :—

ANNUAL RATES OF MORTALITY PER 10,000 IN AUSTRALIA 1881–90, 1891–1900, AND 1901–10.

Age	Males			Females.		
	1881–1890	1891–1900	1901–1910.	1881–1890.	1891–1900.	1901–1910.
0 . ..	1,325	1,184	951	1,157	1,014	795
10 .. .	25	23	18	24	20	16
20	71	47	37	53	39	33
40 .. .	113	97	82	104	84	72
60 .. .	323	303	258	240	225	192
80	1,365	1,384	1,380	1,245	1,224	1,133

Up to age 60 there is quite a remarkable diminution in the rate of mortality in each sex. This, indeed, holds up to 70, but from that age onwards the rates are in some cases slightly higher in the later than in the earlier decennia This is, of course, a consequence of the fact that if deaths are postponed by diminishing the number dying early, they will tend to swell those at higher ages, and under ordinary circumstances must increase the rates at such higher ages.

A representation of the position, which from some points of view is more satisfactory than either of the foregoing is that which exhibits for various ages what is known as the "expectation of life," *i.e.*, the mean duration of life beyond a given age of those who attain that age.

The following table furnishes for various ages the results deduced from the Australian experience for each sex for each of the three decennia under review:—

AUSTRALIAN EXPECTATION OF LIFE, 1881–90, 1891–1900, AND 1901–10.

Age	Males			Females.		
	1881–1890.	1891–1900.	1901–1910.	1881–1890.	1891–1900.	1901–1910.
	Years.	Years.	Years.	Years.	Years.	Years.
0 ..	47·2	51·1	55·2	50·8	54·8	58·8
10	48·9	51·4	53·5	51·9	54·5	56·4
20 .	40·6	42·8	44·7	43·4	45·7	47·5
40 .. .	26·5	27·6	28·6	29·1	30·5	31·4
60 . .	13·8	14·0	14·3	15·4	15·9	16·2
80 . ..	5·1	5·0	5·0	5·3	5·5	5·7

These results shew that for the whole of life there has been an increase of no less than eight years both for males and females in the expectation of life when the experience for 1901–10 is compared with that for 1881–90. Similarly there has been an increase of about four and a half years in the expectation for each sex at age 10 and an increase of slightly more than four years in the expectation for each sex at age 20.

The only country for which similar details are immediately available for the decennium 1901–10 is Sweden, the figures for which country, in comparison with those for Australia, are given in the following table:—

COMPARISON OF AUSTRALIAN LIFE TABLE 1901–10 WITH THAT FOR SWEDEN, 1901–10.

Age.	Number Surviving.		Rate of Mortality, Per 1,000		Expectation of Life.	
	Australia, 1901–10.	Sweden, 1901–10.	Australia 1901–10.	Sweden, 1901–10.	Australia, 1901–10.	Sweden, 1901–10.
			MALES.			
0 ..	1,000	1,000	95·1	92·6	55·2	54·6
20 ..	845	817	3·7	6·4	44·7	45·9
40	759	719	8·2	7·6	28·6	30·8
60	568	566	25·8	20·7	14·4	16·1
80	143	194	138·0	120·8	5·0	5·2
			FEMALES.			
0	1,000	1,000	79·5	75·9	58·8	57·0
20 .. .	865	831	3·3	5·3	47·5	47·7
40	780	735	7·2	7·0	31·5	32·5
60	632	604	19·2	16·6	16·2	17·2
80	214	237	113·3	109·4	5·7	5·6

The following table furnishes a comparison of the Australian expectation of life for successive vicennial ages for the decennium 1891–1900. with similar information relating to a corresponding period for the principal European countries for which such information is available :—

COMPARATIVE TABLE OF EXPECTATION OF LIFE. YEARS 1891–1900.

Age in Years.	Australia, 1891–1900.	Sweden, 1891–1900.	Norway, 1891–1900.	Denmark, 1895–1900.	Netherlands, 1890–1899.	France, 1898–1903.	Belgium, 1891–1900.	England and Wales, 1891–1900.	Finland, 1891–1900.	Italy, 1899–1902.	Germany, 1891–1900.	Austria, 1900–1901
						MALES.						
	Years.	Years.	Years.	Years.	Years.	Years.	Years	Years	Years	Years.	Years.	Years
0 .	52·2	50·9	50·4	50·2	46·2	45 7	45 4	44 1	42·9	42 8	40·6	37·8
20 .	44·7	44·7	43·6	44 5	43·4	41·5	41 8	41 0	42·0	43·1	41·2	40·1
40 . .	28·6	29 9	30·6	28·9	28·1	27·1	26·7	25·6	27·3	28·0	25·9	25·5
60	14·3	15·4	16·4	14·7	14·0	13·8	13·4	12 9	13·5	13·6	12·8	12·6
80 ..	5·0	4·9	5·6	4·9	4·7	4·9	4·6	4·6	4·3	4·3	4·2	4·4
						FEMALES.						
0 . ..	54·8	53·6	54·1	53·2	49·0	49·1	48·8	47·8	45·6	43·2	44·0	39·9
20 .	45·7	46·8	46·5	46·7	44·8	44 0	44·4	43·4	44·2	43·2	43·4	40·8
40 . ..	30·5	51·7	32·3	31·2	29·7	29·6	29·5	27·8	29·5	28·7	28·1	26·6
60 .. .	15·9	16·6	17·5	16·0	15·0	15·1	14·8	14·1	14·6	13·7	13·6	12·8
80 .. .	5·5	5·4	6·1	5·3	5·0	5·4	4·9	5·0	4·9	4·2	4·5	4·5

Comparing the Australian rates of mortality with those of Sweden for the decennium 1901–10 it will be seen that the incidence is markedly different in the two countries. The effect of this upon the economic aspect of the population of the two communities will best be seen by analysing the respective expectations of life so as to shew, in regard to each person born, the average time lived in the three groups of " Dependent Age " (under 15), " Supporting Age " (15 to 65), and " Old Age " (above 65).

Treated in this manner the life tables furnish the following results :—

ANALYSIS OF AUSTRALIAN AND SWEDISH EXPECTATIONS OF LIFE, 1901–10

Period.	Age	Average Time Lived in Period by Each Person Born.			
		Males.		Females.	
		Australia, 1901–10, Experience	Sweden, 1901–10 Experience	Australia, 1901–10, Experience.	Sweden, 1901–10, Experience.
		Years.	Years.	Years.	Years.
Dependent Age	–15	13·14	12·94	13·40	13·20
Supporting Age .. .	15–64	36·56	35 20	38·19	36·30
Old Age	65–	5·50	6·41	7·25	7·50
The whole of life		55·20	54·55	58·84	57·00

This table indicates that for the economically important period of life, viz., from 15 to 65, each male born in Australia experiences on the average 1·36 years of life more than a male born in Sweden, and each female born in Australia 1·89 years of life on the average more than a female born in Sweden. This is a matter of considerable importance when it is remembered that the mortality experience of Sweden is practically the best in Europe.

2. The Trade and Finance of Australia.

The subject of the oversea trade of Australia has been treated at some length in Chap. XI., section 4. What is added here is supplementary to that article. The facts which go to shew that there has been corresponding expansion of the internal trade are derivable from railway statistics and have been already set out at some length in the chapter mentioned, section 7.

(a) Oversea Trade.

Although far removed from the great centres of population, the Commonwealth of Australia occupies a relatively high position amongst the trading countries of the world. To illustrate this, various tables have been compiled, and are given hereinafter. These review the situation for the past thirty years. In these tables the results are shewn either for quinquennial groups, or at quinquennial intervals. Tables so built up have two advantages over others with only annual intervals. In the first place a much larger period can be brought within the limits of a single table; and in the second place accidental fluctuations from year to year, due to non-recurring causes, are either eliminated or greatly reduced. In the period under review there were three of these fluctuations, to which reference will be made in the proper place.

The volume of a country's external trade, and its amount per head, is a very fair index of its prosperity, provided that due allowance be made for the important factors that may influence it. The first table shews the oversea trade of the Australian Commonwealth under the three headings of "Recorded Value," "Value per Inhabitant per annum," and "Percentage of Imports upon Exports":—

OVERSEA TRADE OF THE COMMONWEALTH, 1881–1912.

Quinquennial Period.	Recorded Value.			Value Per Inhabitant Per Annum.			Percentage of Exports Upon Exports.
	Imports.	Exports.	Total Trade.	Imports.	Exports.	Total Trade	
	£,1000	£1,000	£1,000	£ s. d.	£ s. d.	£ s. d.	
1881–1885 .	174,474	140,274	314,748	14 5 3	11 9 3	25 14 6	80·4
1886–1890	173,377	132,895	306,272	11 16 7	9 1 4	20 17 11	76·6
1891–1895	136,675	168,413	305,088	8 4 0	10 2 0	18 6 0	123·2
1896–1900 .	168,815	205,468	374,283	9 5 5	11 5 9	20 11 2	121·7
1901–1905	196,289	256,188	452,477	10 1 8	13 3 2	23 4 10	130·5
1906–1910 .	257,539	346,683	604,222	12 5 7	16 10 8	28 16 3	134·6
Year 1912 .	78,159	79,096	157,255	16 16 7	17 0 7	33 17 2	101·2

It will be derived from this table that the value of trade per head per annum started at £25 14s. 6d. in the first quinquennium, fell rapidly for ten years, and then recovered itself, at first slowly and afterwards more rapidly. The first quinquennium, and part of the second, formed a period of large public borrowing and trade activity, but this was followed by a period of stress, culminating in the acute financial crisis of 1892, when several of the banks suspended payment. Recovery began to be apparent in 1896 and continued steadily until 1903–4, when there was a somewhat severe set-back owing to the drought of 1902. Since then, however, the advance has been almost continuous, the only check being in the years 1908–9, when, as a consequence of the American financial crisis of 1907, there was a fall in the prices of Australian staple products.

The third column of the table shews the relation between imports and exports for the period. For the first ten years the balance of trade was in favour of imports—the consequence of large public borrowing in that period. From that time until 1911, the balance was in favour of exports, the normal situation for a debtor country which is not largely increasing its public debt. In 1912, however, there was heavy public borrowing, and the imports were so largely increased in consequence, that imports and exports for that year practically balanced each other.

(b) Public Debt.

Reference has been made in the previous paragraph to Australia as a debtor country, and mention may now be made of the aggregate public debt of the various States. The table hereunder shews the increase since 1881 at quinquennial intervals, and the increase per head of population, and both will be be seen to be extremely large—

PUBLIC DEBT OF AUSTRALIAN STATES.

Year.	Amount.	Per Head.	Year.	Amount.	Per Head.
	£	£ s. d.		£	£ s. d.
1881	66,306,471	29 4 6	1901	203,518,275	53 14 6
1886	117,323,018	42 15 10	1906	238,427,820	58 14 9
1891	155,117,773	48 10 8	1913	*294,482,164	61 6 1
1896	180,623,886	51 5 7			

* Exclusive of Commonwealth Debt, £7,430,945.

This has been the occasion from time to time of much extraordinary and irrelevant criticism by persons who failed to recognize that the loan money has been applied largely to the improvement of internal communication (absolutely essential to the development of a country which has no large and navigable waterways), to harbor works, water supply, or other great public utilities. The Australian States thus possess solid assets which practically counterbalance the debt, inasmuch as they nearly pay the interest bill. That this is a fair statement of the case can be illustrated as follows:—In the financial year ended 30th June, 1912, the States obtained in revenue from their "Public Works and Services" the sum of £23,690.269. The expenditure during the same period was £15,952,803, leaving a surplus of £7,737,466. The interest payments for the year amounted to £9.479,003. The profit on the "Public Works and Services" is thus sufficient to meet all the interest payments, except an amount of £1,741,537. This, if capitalized at the average rate of interest paid by the States, amounts to about £50,000,000, which is thus the amount of the public debt which was not directly reproductive at that time.* Even this, however, is spent on immigration, or in other ways which indirectly increases the wealth of Australia. The country is thus not saddling itself with a mere dead weight, but is rather in the position of a company which for business principles is constantly enlarging its capital, and is in a very different position financially from a country whose public debt has been incurred in, say, war.

* The Public Debt at 30th June, 1912, was £277,124,095.

(c) Accumulation.

Under this heading will be included deposits in ordinary banks, deposits in savings banks, etc., for the period under review.

The following table (Accumulation i.) shews the amount of deposits in the ordinary banks for five-yearly intervals. The amounts given do not, of course, represent the savings of the people, but rather the foundation for the volume of trade. The fluctuations to be observed in the case of a former table (Oversea Trade) are reproduced here in an even more marked degree :—

ACCUMULATION (I.) DEPOSITS IN ORDINARY BANKS.

Year, 30th June.	1881.	1886.	1891.	1896.	1901.	1906.	1913.
	£	£	£	£	£	£	£
Amount £1,000,000	50·932	75·468	97·692	85·680	91·487	106·515	149·828
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Per Head ..	22 8 11	27 10 7	30 11 3	24 6 6	24 2 8	26 1 6	31 4 0

A second table (Accumulation ii.) furnishes the number of depositors in savings banks during the period and the amount at credit. These show steady advances during the 30 years, uninfluenced by any fluctuation.

ACCUMULATION (II.).—SAVINGS BANKS STATISTICS.

Year	Number of Depositors.	Amount at Credit.	Amount Per Head of Population.
1881	250,070	7,893,464	3 9 7
1886	396,735	10,284,530	3 15 0
1891 .. .	614,741	15,536,592	4 17 3
1896	764,650	24,330,214	6 18 2
1901	964,553	30,882,465	8 3 0
1906	1,185,608	38,286,219	9 9 10
1911 .. .	1,600,112	59,393,682	13 8 5
1913*	1,961,215	75,462,850	15 14 4

* Includes Commonwealth Savings Bank.

A third table (Accumulation iii.) shews the amounts paid in insurance premiums (ordinary business). The figures from 1881–1906 include the foreign business of Australian companies, but exclude the Australian business of foreign companies :—

ACCUMULATION (III.).—PREMIUM INCOME (NEW AND RENEWAL) OF AUSTRALIAN COMPANIES.*

Year.	1881.	1886.	1891.	1896.	1901.	1906.	1912.
	£	£	£	£	£	£	£
Amount	887,894	1,406,854	2,144,695	2,328,325	2,917,552	3,619,918	4,938,315
Amount per head of	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
population ..	0 7 10	0 10 3	0 13 5	0 13 3	0 15 5	0 17 10	1 1 3

* Including (till 1906) foreign business of Australian companies, but excluding Australian business of foreign companies.

The two tables taken together shew that, despite the charges of private extravagance, not unfrequently levelled against Australians, large and increasing sums are put by for purely provident purposes. This, moreover, is exclusive of the money invested in building societies, etc. It is just possible that persons whose experience is mainly of the old world are apt to mistake the higher standard of living for improvidence.

(d) Financial Relationship between Commonwealth and States.

A few words may be added on the changes in public finance brought about by Federation. At the time of Federation the main revenue of the States was derived from taxation (direct and indirect), and income from "Public Works and Services." For the first ten years after Federation, the financial relations between Commonwealth and State Governments were regulated by Section 87 of the Constitution, known generally as the "Braddon Clause." This provided that the Commonwealth should, until 31st December, 1910, and thereafter, as long as Parliament should decide, retain for its own use an amount not exceeding one-fourth of the net revenue from customs and excise duties, the balance to be returned to the States. The original framers of the Constitution only contemplated a moderate Federal expendidure, and doubtless considered one-fourth of the customs and excise revenue sufficient, as it certainly was at first. After six or seven years, however, it began to be realized that the Federal Government, with its heavy self-imposed commitments for large national purposes, such as defence, old-age pensions, etc., must face a largely increased expenditure. Consequently, on the expiration of the Braddon clause, a new arrangement was made, for a period of ten years, on terms much more favorable to the Commonwealth Government. By the terms of the new agreement, the Commonwealth retains the whole of the customs and excise revenue, and makes to each State, by monthly instalments, an annual subsidy equal to 25s. per head of the population of that State, as at 31st December of the financial year in question. Special annual subsidies are being made, in addition, to Western Australia and Tasmania, as compensation for the dislocation of their finances, which occurred when they surrendered control of their customs and excise revenue to the Commonwealth. These arrangements are subject to alteration, or may be determined at the expiration of ten years (1920).

3. Productive Industries.

(a) Value of Production.

The productive industries of Australia may be classified under the headings of agricultural, pastoral, dairying, etc., forestry and fisheries, mining and manufacturing. From the point of view of value of production, manufacturing has taken the lead for the past two years—a position previously held by the pastoral industry. At present agriculture fills the third place, mining, dairy and poultry farming, and forestry and fisheries following in the order named.

The development of these various industries having already been fully described in previous chapters of this book, this further reference to them must be considered as merely supplementary, and as dealing with them purely from a statistical point of view.

The inaccuracy of statistical information, and the absence of uniformity of its collection by the several States prior to 1906, and in the case of manufacturing for three years later, render it extremely difficult to form an estimate of the probable value of production during the earlier years. Careful estimates have, however, been made, and may be accepted as being sufficiently correct to form a basis for comparative purposes, and also to furnish evidence of the development that has taken place in the several industries during recent years.

ESTIMATED VALUE OF PRODUCTION FROM AUSTRALIAN INDUSTRIES.

Year.	Agricultural.	Pastoral.	Dairy, Poultry, and Bee Farming.	Forestry and Fisheries.	Mining.	Manufacturing.	Total.
	£ 1,000	£ 1,000	£ 1,000	£ 1,000	£ 1,000	£ 1,000	£ 1,000
1901 ..	23,835	27,150	9,740	2,772	22,016	27,191	112,704
1906 ..	25,349	45,389	13,611	4,879	26,622	33,205	149,055
1912 ..	45,754	51,615	20,280	6,432	25,629	57,022	206,732
			PER HEAD OF MEAN POPULATION				
	£	£	£	£	£	£	£
1901 ..	6·29	7·16	2·57	0·73	5·81	7·17	29·73
1906 ..	6·24	11·18	3·35	1·29	6·53	8·18	36·71
1912 ..	9·85	11·11	4·37	1·38	5·52	12·28	44·51

(b) Agriculture.

Prior to the gold discoveries, and the consequent large influx of population, very little attention was paid in Australia to agriculture, the bulk of the food-stuffs being imported. It is estimated that only 491,000 acres were under cultivation in 1850. The growing demand for agricultural products, however, was soon reflected in the increased area cultivated, and from that date, irrespective of fluctuations incidental to climatic conditions in certain seasons, a consistent and satisfactory development has been in evidence.

From 1871 to 1912 the area under crop increased from 2,346,000 acres to 13,038,000 acres, or by 456 per cent., while the total value of produce increased from £8,941,000 to £45,754,000, or by 412 per cent.

(c) The Pastoral Industry.

The pastoral industry is far the most important of the primary productive industries of the Commonwealth, and in 1912 represented £51,615,000, or nearly 34 per cent. of the total value of those industries. Wool, of course, is the main factor in this yield, the values of wool and sheepskins exported during 1901, 1906, and 1912 being £15,237,000, £22,646,000, and £26,355,000 respectively. The recent revision of the tariff of the United States of America will probably have the effect of opening up a very large market for Australian mutton and other meat products, in addition to largely increasing the demand for our wool.

(d) Dairy, Poultry, and Bee Farming.

The development of the dairying industry in Australia has been rapid during the last few years. The exports of butter, which in 1901 were valued at £1,451,000, rose to £3,240,000 in 1906; five years later, in 1911, they represented no less a value than £4,637,000, having more than trebled during the decade.

The total value of output of dairy, poultry, and bee farming in 1906 was £13,611,000; in 1908, £15,045,000; in 1910, £17,387,000; and in 1912, £20,280,000.

(e) Forestry and Fisheries.

(i.) *Forestry.*—The forests of the Commonwealth cover about 102,000,000 acres, the area specially reserved being about 27¾ million acres. The uses of the more important of Australian timbers are many and various, and for durability and beauty are unsurpassed by any timbers in the world. The quantity of local timber sawn or hewn in Australia during 1902 was 352 million superficial feet, five years after it was over 416 million, while in 1912 over 667½ million superficial feet of Australian timber was sawn or hewn throughout the Commonwealth.

A considerable quantity of wattle and other bark used for tanning purposes is produced. During 1912 the local tanneries used 26,739 tons, while 8,402 tons were exported.

(ii.) *Fisheries.*—Valuable food fishes abound in the coastal waters of Australia, while the fresh water rivers and lakes yield abundant supplies both of natural and acclimatized species. Pearls and pearlshell are obtained in Western Australia, Queensland, and the Northern Territory, the last two places also exporting quantities of bêche-de-mer and tortoiseshell.

The enhanced value of the combined production of forestry and fisheries during the past few years has been very satisfactory, the value of output having increased from £4,879,000, in 1906, to £6,432,000, in 1912.

(f) Mining.

Although the annual return from mining is now considerably less than that yielded by the pastoral, agricultural, and manufacturing industries, nevertheless, the value of mineral production during 1912 amounted to £25,629,238, an amount that had only been exceeded by the 1906 output, the total value of which was £26,621,796. To the end of 1912 the Commonwealth mineral production totalled over 810 million pounds, to which gold contributed £546,080,000; silver and lead, £70,069,000; copper, £62,394,000; tin, £31,577,000; and coal, £78,570,000.

The following table shows the value of mineral production during certain years from 1851 to 1912:—

AUSTRALIAN MINERAL PRODUCTION, 1851–1912.

Year.	Gold.	Silver and Lead.	Copper.	Tin.	Coal.	Other.	Total.
	£	£	£	£	£	£	£
1851	1,319,932	1,778	309,324	11,937	25,739	2,190	1,670,900
1853	12,737,564	1,787	176,355	11,937	78,252	2,265	13,028,160
1860	10,373,280	11,926	443,044	11,937	235,930	3,000	11,079,117
1880	4,906,903	46,496	667,545	841,128	644,801	43,520	7,150,393
1890	5,261,217	2,857,849	339,978	646,157	1,470,267	268,611	10,844,079
1900	13,578,438	3,044,524	1,802,215	550,256	2,019,303	395,239	21,389,975
1910	11,553,840	2,224,687	2,389,412	950,768	3,684,041	*2,412,443	23,215,191
1912	9,879,928	3,876,251	3,244,550	1,348,992	4,418,025	*2,861,492	25,629,238

* Including zinc, 1910, £1,289,781 and £1,766,459.

Since the year 1900 the value of the mineral output has not progressed very rapidly, the chief cause being the steady decline in the gold yield. The other important minerals, however, shew a substantial increase in production.

(g) Manufacturing.

Statistics relative to the manufacturing industries are not available for the Commonwealth as a whole prior to 1903, and are even then not complete. The growth of these industries since that date has been very considerable. The number of factories in 1903 was 11,551, as compared with 14,878 in 1912, while the number of hands employed has increased from 195,810 to 327,456 in the same period. Similarly the total amount of salaries and wages paid has risen from about £14,000,000, in 1903, to £31,287,492, in 1912. The total value added in the process of manufacture in 1907 was £38,063,153, as compared with £60,499,787 in 1912.

As regards capital invested in manufacturing industries it may be noted that the approximate value of land and buildings in connection with factories increased from £23,056,000 in 1903 to £34,809,000 in 1912, while that of plant and machinery employed in factories increased from £20,653,000 in 1903 to £34,461,000 in 1912, that is to say, the total fixed capital employed in these industries rose from £43,709,000 to £69,270,000—an increase of 58½ per cent.

4. Land Legislation and Settlement.

In the early days of Australian colonization, land could be alienated only by grants and orders from the Crown, and the power of making these was vested solely in the Governor. In 1787, land was granted to liberated convicts only, but two years later the privilege was extended to free immigrants or to marines serving in Australia and desirous of settling in the colony.

Tenure under leasehold was not adopted till the year 1811, and in 1834 leases were granted under a covenant to convert the same into grants on the fulfilment of certain conditions, often merely nominal. Before this, however, the principle of alienation of land by sale to free settlers had been introduced by Sir Thomas Brisbane, the first land sale taking place in Sydney in 1825.

The system of grants was abolished in 1831 except for public or charitable purposes, and purchase at public auction was made practically the sole means of alienating Crown lands. In the same year the principle of selection was introduced into the land laws of Australia.

A new element was embodied in the Imperial Act of 1842, namely, the provision that, subject to a primary charge for survey, half the proceeds of the land sales were to be used to defray the cost of immigration of persons to the colony in which the revenue accrued.

Under another Act, viz., in 1847, a new classification of lands took place, and, while sales by auction were maintained, a system of leasehold was introduced, giving the lessee a right of purchase during the currency of the lease at an upset price of £1 per acre, or, on the expiration of the lease, a pre-emptive right at the same price over all or any part of the land.

The land legislation of New South Wales remained practically unaltered from 1847 to 1861, and, as the several colonies received their own Constitutions, their land laws for the most part remained identical with those of the mother colony until such time as local conditions and requirements called for new legislation. The influence of New South Wales was not felt to the same extent in South Australia and Western Australia, where other conditions prevailed and where land settlement was effected by land laws of a special and novel character. In the first chapter of this book reference has already been made to Wakefield's scheme of settlement in South Australia.

When the excitement of the gold rush had subsided and the interest in gold digging was declining, the number of people desiring to settle on the land so increased that the question of land settlement became of the first order of importance. As a consequence, greater encouragement was given to settlers by making the conditions of tenure more liberal, and legislation was enacted to facilitate the establishment of an agrarian population side by side with the pastoral tenants. Men with limited capital were enabled to take up land under conditions that ensured a reasonable chance of success and at the same time the Acts passed aimed at preventing land being made the subject of mere speculative selection without *bonâ fide* intention of settlement.

In 1858, South Australia enacted an important piece of land legislation, viz., the "Real Property Act." This Act, originated by Sir Robert R. Torrens, and subsequently adopted by all the States and by New Zealand, has greatly facilitated all dealings in land by providing for such registration of title as not only simplifies the investigation of such title, but also secures the registered owner against all parties.

Many and varied were the experiments in land legislation made by the several States. Acts from time to time were repealed, amended, or elaborated as new conditions emerged, or difficulties presented themselves. Even at the present time, though there is a considerable similarity between the principal form of tenure in the States, the terms and conditions vary very considerably.

In all the States, what are known as Closer Settlement Acts have been passed. It was found that the value of the produce of a large estate, originally considered as being at its full capacity, compared unfavorably with the returns which could be obtained from the same area when subdivided and cultivated by settlers.

Under the Acts mentioned, the State Governments resume, either under agreement or under compulsory purchase, large estates which have in past years been alienated by the Crown, and, after cutting them up into areas of suitable size, throw them open to settlement on easy terms and conditions. Of the total area of the Commonwealth, on the 31st December, 1912, 5·4 per cent. was alienated, 2·7 per cent. was in process of alienation, 45·1 per cent. was held under lease or licence, while the remainder, 46·8 per cent., was unoccupied.

5. Immigration.

While recognizing fully the desirability of increasing the population of their respective States by immigration, the State authorities, long prior to Federation, deemed it wise to impose certain restrictions upon the character of the immigration. The influx of Chinese, for example, was limited by stringent statutory provisions, and Acts were passed in most of the States restricting the immigration of other, chiefly Asiatic, races.

Further restrictions were placed upon the admission of persons who were undesirable as inhabitants, either for medical or moral reasons, or who were likely to be an economic burden upon the community. On the Federation of the States in 1901, the power to make laws with respect to immigration passed into the hands of the Commonwealth Government.

At the present time, besides the restrictions mentioned above, an immigrant may be required to pass a dictation test before being admitted into

the Commonwealth. It may be stated that in general practice this test is not imposed upon persons of European race.

Since the year 1861 the net immigration, that is, the excess of arrivals over departures, has been 959,515 ; while for the same period the natural increase, that is, the excess of births over deaths, has been 2,628,259.

To shew, however, the present activity of the several States in the matter of immigration, it is necessary to give only the figures for the year 1912, during which the arrivals from overseas into the Commonwealth were 166,958.

The departures in the same year amounted to 83,217, leaving a net immigration total of 83,742—a number which easily constitutes a record.

The net immigration for 1912 is also remarkable for the fact that it actually exceeded the natural increase of the population, which was 80,911.

In the earlier days of settlement in Australia, State-assisted immigration played an important part.

Occasionally, however, one or other of the States would discontinue the practice, but of late years the policy has been revived and is now being vigorously carried out by all the States except Tasmania.

Assistance is granted towards the payment of passage money to persons desiring to settle on the land or to engage in farm or dairy work, to domestic servants and to other persons who can satisfy the Agents-General that they will make suitable settlers ; while persons resident in Australia may nominate their relatives or friends to come out by assisted passages.

During 1913, assistance was granted to 39,796 immigrants, making the total number assisted from the earliest times, 812,491.

6. The Postal Service.

The development of a postal service in a large and sparsely populated territory is necessarily a work of difficulty and expense. In its comparatively short history, Australia has inaugurated a postal service which reaches practically every inhabited part of the continent, although its population is only about one-twentieth that of the United States of America, while its area is the same.

The first office for postal purposes was established in Sydney in 1809, the charge for the delivery of each letter being one shilling ; but it was not until 1828 that a system of general post office communication was inaugurated. Rates of postage depended entirely upon the distance and difficulty of transmission, and varied from three pence to a shilling per letter.

In Tasmania, the mails in 1824 were delivered once a fortnight by foot post, while in 1835 a mail cart made the journey twice a week from Hobart to Launceston (121 miles) in nineteen hours. A post office was established in Melbourne in 1837, with a fortnightly service between that city and Sydney. It is interesting at the present to notice a clause in the Postal Amendment Act passed in 1840 in New South Wales, which made it compulsory, under a penalty of from £10 to £50, for the masters of all vessels entering a port " to give timely notice of the near approach thereof, either by the ringing of a bell or by such other signal as may reasonably be expected to be distinctly heard or seen by the postmaster, a sufficient time before the actual arrival of such steam-boat or other vessel to enable him to receive or despatch any mail on board."

In the year 1841, there were only 102 post offices in Australia, 56 being in New South Wales, 43 in Tasmania, and 3 in what is now Victoria.

Subsequent to the discovery of gold, the history of the postal services reveals a remarkable rate of increase in postal correspondence, as is seen from the following table:—

DEVELOPMENT OF POSTAL SERVICES.

Particulars.	1861.	1881.	1901.	1912.
Number of post offices ..	1,006	3,018	5,008	8,225
Number of letters and post cards dealt with.. ..	12,844,000	67,640,000	220,177,000	479,673,000
Number per post office ..	12,700	22,400	43,900	58,300
Number of letters and post-cards dealt with per 100 of population	1,099	2,932	5,756	10,134

7. Scientific Societies and Liberal Educational Effort.

Despite the adverse influences incidental to the development of a young country, higher education and the promotion of scientific effort were not neglected even in the earliest days of Australia, as the history of the establishment of scientific societies, superior schools, and the universities abundantly shews. To some of these we shall now refer.

The origin of the Royal Society of New South Wales dates as far back as 1821, when, under the name of the Philosophical Society of Australasia, it was founded by Sir Thomas Brisbane, who was its first president. Its present title was acquired by Royal sanction in 1866, its object being the promotion of art, science, literature, and philosophy. Some of the papers of the old Philosophical Society published in 1825 contain much that is interesting of the early history of Australia. The society has now over 300 members, while its exchange list comprises the names of 370 kindred societies. The society possesses a very fine library of about 21,000 volumes and pamphlets, and issues annually a journal of 500–600 pp., the 47th volume of which has already appeared.

The Royal Society of Victoria dates back to 1854, the year preceding that during which its constituent origins, viz., the Victorian Institute for the Advancement of Science and the Philosophical Society of Victoria, were amalgamated, under the title of the Philosophical Institute of Victoria. Its present title was received in 1860. The constitution of the society states that it was founded "for the promotion of art, literature, and science," but for many years past science has monopolized its energies. Up to the present 56 volumes of publications have been issued. The society has a fine library of 10,000 volumes, and exchanges with 326 kindred bodies.

The Royal Society of Queensland was instituted in 1884, being formed "for the furtherance of the natural and applied sciences, especially by means of original research." At latest date the members numbered over 100; publications, 75 volumes; library, 4,000 volumes; and societies on exchange list, 142.

The present Royal Society of South Australia grew out of the Adelaide Philosophical Society, which was founded in 1853, its object being the discussion of all subjects connected with science, literature, and art. Despite this programme, the tendency of the society became purely scientific. Permission

to assume the title "Royal" was obtained in 1879, the society thenceforward being known as the Royal Society of South Australia. The membership is now about 100, and the exchange list numbers 253. Up to the present the society has issued 36 volumes of proceedings, and six of memoirs, exclusive of individual papers published in earlier years.

The Royal Society of Tasmania, the first "Royal Society" to be established outside the United Kingdom, was founded in 1843, and in the list of the first corresponding members appear the names of Captains Ross and Crozier, of H.M.S. *Erebus* and *Terror*. The society has a membership of nearly 200, and a library of 8,000 volumes. Annual volumes of proceedings have been published since 1844, and exchanges are made with 140 kindred bodies.

The Australasian Association for the Advancement of Science was founded in 1888, and has its head-quarters in Sydney. It meets biennially in each State in turn. Up to date, thirteen volumes of proceedings have been issued. and the exchange list numbers 250. The Linnean Society of New South Wales, founded in 1875, maintains three investigators engaged in research work.

The principal scientific society in Western Australia, viz., the Natural History and Science Society of Western Australia, has grown out of the Mueller Botanic Society, founded in 1897, and has for its object the study of natural history and pure science, promoted by periodical meetings and field excursions. Its membership is 118, and since its establishment twenty journals of proceedings have been issued.

There are a number of lesser societies, among which may be mentioned the British Astronomical Society, which has a branch in Sydney, and the Royal Geographical Society of Australasia, which has branches in Melbourne, Brisbane, and Adelaide, while Melbourne is the head-quarters of the Royal Australasian Ornithological Union. In 1901 the Australian Historical Society was founded in Sydney, having for its object the collection and preservation of all books, records, relics, and cognate matters having reference to Australian history.

There are also professional societies, among which may be mentioned the Sydney, Melbourne, and Brisbane branches of the British Medical Association; and the Institutions of Surveyors of New South Wales and Victoria.

As far as can be ascertained, the total number of libraries in the Commonwealth at the latest available date was about 1,500, the number of books contained therein being estimated at nearly 3,000,000. In each of the capital cities there is a well-equipped public library, the institutions in Sydney and Melbourne, especially, comparing very favorably with similar institutions in other parts of the world. An interesting table, shewing the number of libraries in receipt of State or municipal aid, is given hereunder :—

SUBSIDIZED LIBRARIES AND BOOKS THEREIN.

Particulars.	N.S.W.	Vic.	Q'land	S. Aust.	W. Aust.	Tas.	Northern Territory
Number of libraries	477	525	203	211	237	32	2
Estimated number of books ..	925,000	1,109,000	304,000	459,000	214,000	106,000	2,700

Amongst other important libraries not included in the above table may be enumerated those at the Sydney University and the Australian Museum, which contain 96,000 and 18,000 volumes respectively. There are also over 500 libraries, with an estimated total of 145,000 volumes, attached to the State schools. In each of the capital cities, and in Launceston, museums devoted to natural history, ethnology, and geology have been established. The Australian Museum in Sydney, founded in 1836, is the oldest institution of its kind in Australia, and contains, *inter alia*, a very valuable and complete set of specimens of Australian fauna. There is a fine Technological Museum in Sydney, with branches in six country centres, the metropolitan institution containing over 109,000 specimens. Valuable research work in connexion with the oil and other products of the eucalyptus has been undertaken by the scientific staff. A similar institution in Melbourne contains upwards of 55,000 specimens. Museums devoted to botany and plant life are established in Sydney, Melbourne, and Hobart; while there are several museums devoted to special objects, such as the "Nicholson" Museum of Antiquities in Sydney, and the Queensland Geological Survey Museum in Brisbane and Townsville. Each of the capital cities, as well as many of the larger towns, have erected art galleries, containing many valuable works by both European and Australian artists.

8. Educational Benefactions.

The Universities of Australia have benefited considerably by private munificence, and so also have other institutions of an educational character, such as Public Art Galleries, Technical Schools, Museums and Libraries, etc.

The most notable public benefactions are those which the Sydney University has enjoyed, donations thereto aggregating nearly £500,000, of which the bequests of Mr. J. H. Challis (£250,000), Sir P. N. Russell (£100,000), and Mr. Thomas Fisher (£20,000) are the most noteworthy.

Melbourne University has received private benefactions totalling £175,000, Sir Samuel Wilson (£30,000), Mr. James Stewart (£25,000), and the Hon. Francis Ormond (£20,000) being the largest contributors. The last-named gentleman also donated £108,000 to Ormond College, one of the affiliated colleges of the Melbourne University.

Sir Thomas Elder and Sir W. Hughes, with sums of £98,000 and £20,000 respectively, are the chief benefactors of the Adelaide University, which has so far received bequests totalling about £154,000.

Other notable benefactions are the collections of Sir Charles Nicholson and Mr. George Masters to the Sydney University, the building for the Natural History Museum given by Sir W. Macleay, the library of Mr. D. S. Mitchell, M.A. (valued at £108,000), given to the City of Sydney, and the Felton Bequest given to the Melbourne Art Gallery, and which returns annually about £8,000 to the trustees of that institution.

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